THE ART
OF
GVNNERY.

VV herein is ſet forth a number of ſeruiceable ſecrets, and practicall concluſions, belonging to the Art of Gunnerie, by Arithmeticke skill to be accompliſhed: both pretie, pleaſant, and profitable for all ſuch as are profeſſors of the ſame facultie.

Compiled by THOMAS SMITH of *Barwicke* vpon Tweed Souldier.

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TO

THE RIGHT HONOV-RABLE PERIGRIN BERTIE KNIGHT,

Lord Willoughbie Beake and Earsby, Lord Gouernour of her Maiesties Towne and Castle of *Barwicke* vpon Tweed, and Lord Warden of the East marshes of *England*, for and anepst *Scotland*, *&c.*

IT is a common opinion, Right Honourable, amongst a great number, who may be tearmed more wayward than wise, that the Art of Souldiery may perfectly be attained in two or three moneths practice, and that any common man in a few weekes trayning, hauing seen two or three skirmishes may be called an expert soldier. Not considering that a Mariner may saile seuen yeares, and yet be farre from a Nauigator. A number of Mechanicall Artificers may labour

diuers yeares,and yet be farre from perfection; and a number of Souldiers may ſerue many yeares,and yet haue but the bare name of a ſouldier. He may well be called a trained ſouldier, that knoweth by the ſound of Drum,& Trumpet,without any voice,when to march,fight,retire,&c.that is able in marching, embattelling, encamping, and fighting, and ſuch like, to performe,execute, and obey the lawes and orders of the field, that hath ſome ſight in the Mathematicals,and in Geometricall inſtruments, for the conueying of Mines vnder the ground, to plant and mannage great Ordinance, to batter or beat down the wals of any Town or Caſtle, that can meaſure Altitudes,Latitudes,and Longitudes,&c. ſuch a one may be tearmed, in my opinion, an expert ſouldier, though hee neuer buckled with the enemie in the field.

Such perfections is well knowne to be in your Honour, that you are furniſhed with theſe and many mo rare qualities in the Art Militarie,and aboue all with wiſedome and noble courage,to performe and execute any honourable enterpriſe whatſoeuer for the honour and ſeruice of God, your Prince and Countrie, the which our proud enemies haue felt to their paine and your euerlaſting fame.

And

And although I my ſelfe bee but one of the meaneſt ſouldiers in this Garriſon now vnder your Lordſhips gouernment (whom we pray long to gouern ouer vs) being brought vp from my childhood vnder a valiant Captaine in Militarie profeſſion, in which I haue had a deſire to practiſe and learne ſome ſecrets touching the orders of the field, and trayning of Souldiers: as alſo concerning the Art of Managing and ſhooting in great Artillerie. I haue thought it good (hearing of no other that hath done the like before) to frame together certaine Arithmeticall and Geometricall rules, to ſhew in part how neceſſarie Arithmeticke and Geometrie is for our profeſſion, the which I haue ſet down in two litle bookes: the one intituled Arithmeticall Militarie Concluſions; the other, The Art of Gunnery: the firſt I wrote two or three yeares ſince, and beſtowed on my Captaine, Sir *Iohn Carie* Knight, the which (God ſparing life) I meane to correct and enlarge, and perhaps put to the Preſſe: This other I haue thought it my part, to offer to your Lordſhips good conſideration, to be ſhrouded vnder your Honourable buckler, to beare off the blowes of enuious tongues, which are euer ready to ſpit their ſpite againſt any vertuous exerciſe: which although it bee

vnworthie to paſſe vnder ſo honourable a protection, I hope your Lordſhip will in indifferent ballance weigh my willing minde, to doe my Countrie good, and your Honour any ſeruice my poore abilitie is able to performe, which if your Honour allow of, I ſhall thinke my paines well employed, and ſhall encourage me hereafter to bring this new found Art into ſome better perfection, ſo farre as my poore abilitie is able to put in practice, or my ſimple skill in the Art will reach to. Thus loth to bee tedious, I ceaſe: beſeeching God to preſerue your Honour with much increaſe of honour, to Gods glorie and your hearts deſire.

Your honours dutifully at command,

THOMAS SMITH Souldier.

To all Gentlemen, Souldiers, Gunners, and all fauourers of Militarie Diſcipline, THOMAS SMITH wiſheth increaſe of happineſſe.

GENTLEMEN, there was neuer Author nor practiſed Gunner euer able (as I am perſwaded) to deſcribe at full, or could ſhew perfectly the efficacie and force that Gunpowder is able to accompliſh, it being a mixture of ſuch a wonderfull operation and effect, as by daily experience wee finde. And although diuers men in diuers ages, haue inuented diuers Engines and Ordinance for offenſiue and defenſiue ſeruices by Gunpowder to bee performed, yet none hath, nor could euer attaine to that full perfection, to know preciſely what ſtrange effects the ſaid mixture is able to worke. Alſo diuers learned men haue inuented many excellent rules pertaining to the Art of Gunnerie, and a great many of them haue and doe erre in the principalls of their inuentions: and the cauſe is, for want of due practice therein. For the Art of Gunnery doth require great practice and experience, to declare the rare ſecrets thereof; which is not for meane men to attaine to, for that the charge is great.

And albeit, I am the leaſt able of a great many to take any matter in hand, pertaining to the ſame Art, being but a ſworne ſcholler thereto, and my abilitie far vnable to put in practice that I would: yet becauſe I haue ſerued a prentizehood twice told ſince I tooke my oath, and neuer hearing of any that hath compiled any Arithmeticall rules or ſecrets (which is the fountaine head from whence all Arts or ſciences doe ſpring) into one volume, I thought it my part and duty (according to my skill) to doe the beſt I could therein, for the

benefit

benefit of others, and that in the plaineſt maner I could, that ſuch as are not well ſeene in numbers Art, might the ſooner vnderſtand the ſame. And albeit I haue herein ſhewed but a few Arithmeticall concluſions belonging to the Art of Gunnerie, yet the experienced Gunner or skilfull Mathematitian, by theſe few may deuiſe a great many moe, for ſeruice offenſiue and defenſiue, by Arithmeticke and Geometrie to be performed. All which concluſions (gentle Readers) I haue thought beſt to frame in eaſie queſtions, ſhewing the anſwers or reſolution thereof. And although they be but meanly framed, I hope you will accept the ſame in good part, the rather, for that they are a young Gunners practices. And if there be ought herein that may profit you, yeeld me your friendly cenſure, I craue no more: or if in any place I haue erred, either gently correct it, or paſſe it with ſilence, or in friendly ſort admoniſh me thereof, I deſerue no leſſe.

There is a great many that can ſpie a mote in another mans eye, that had need to haue a beame pulled from their owne: ſome will ſcan very curiouſly, and ſooner find two faults than amend one. If you be of that minde (friendly readers) I minde not to make you my iudges.

The widowes mite was aſwell accepted as the gifts of the wealthy. A ſouldier in Alexanders campe, in the dry deſert preſented the King his helmet full of cold water, ſaying, If I could haue gotten better drinke, your Grace ſhould haue had part: the which the King gently accepted and liberally rewarded, anſwering, I wey not the gift, but thy willing minde. But I ſeeke no reward for my trauell, but onely you will weigh my minde is willing to do my Countrey good, and to profit the readers: and not to carpe with Momus, nor diſdaine with Zoilus, nor ſooth with Zantippus. In ſo doing you ſhall encourage me to ſet penne to paper, and to flie a higher pitch

pertaining

pertaining to this new found Art. Otherwiſe, if you ſpit out your ſpite againſt me for my good will, I will as meanely account of your malice, and ſo as I finde you, looke to haue of mee. From my poore houſe in Barwicke vpon Tweed this 2. of May, 1600.

Your friend and wel-willer,

Thomas Smith Souldier.

PETER LVCAS CANNONNIER in commendation of the Author and his booke.

SHake ſilly pen to write of art, to him where art doth dwel,
And ſay, the want of Eloquence doth ſo thy hand repell,
That farre thy Muſe vnable is to praiſe the Authors skill:
Nor canſt thou paint thy minde, nor finely tell thy will.
But as there needs no ſigne at dore, whereas the wine is pure,
So need not I commend this worke, it all men will allure,
To loue the Smith that forg'd this worke, who hath ſuch Art in ſtore,
That better is than Art which trieth gold from ore,
As our proud foes haue found, and felt by Ordinance might,
And ayde of the almighty Ioue, who doth defend our right.
Therefore good Zeale go poſt-haſt vnto fame,
And bid her giue this booke an euer-liuing name.

PERER LVCAS Gunner.

RICHARD

RICHARD HOPE Gentleman in commendation of the worke.

TO tell a tale without authoritie,
Or faine a fable by inuention,
The one proceeds of quicke capacitie,
The other ſhewes but ſmall diſcretion.
Who writes concluſions how to vſe a peece,
In my conceit deſerues a golden fleece.

Who takes in hand to write of worthy warre,
And neuer march'd where any warre was made,
Nor neuer hopes to come in any iarre,
But tels the triall, knowing not the trade;
To write of warre, and note not what it is,
May well be thought a worke begun amiſſe.

But he that by his ſtudie makes it knowne,
What thing warre is, and whereof it proceeds,
Defenſiue and offenſiue reaſons ſhewing,
To thoſe that gape for honor by their deeds,
A worthie worke who doth not count the ſame,
In my conceit he doth a ſouldier ſhame.

If ſo: Smith's *trauell cannot well offend,*
For ſo he meant before he ſet it forth,
And if it chance to come where Souldiers wend;
Hee it commands to ſeeme of little worth:
For what he writes, he writes to honour thoſe,
Which wade in warres to triumph ouer foes.

Richard Hope Souldier.

RICHARD ROTHERVPPE Gentleman in commendation.

THat man whom Martiall attempts
May raiſe to honour high,
Let him peruſe with learned skill,
Smiths *worke of Gunnerie.*

That fountaine which ſuch ſprings ſends forth,
Can neuer drie remaine:
I meane the Ground of Arts, from which
All ſcience we attaine.

As Grammer, Muſicke, and Phyſicke,
With high Aſtronomie:
And other Arts Mathematicke,
And braue Geometrie.

This Art of Gunnerie likewiſe,
Amongſt the reſt let ſtand,
Whoſe god-father this Author is,
Which tooke the ſame in hand.

Whoſe knowledge in this famous Art,
Deſerues eternall fame,
For his concluſions excellent
Doth well deſerue the ſame.

Richard Rotheruppe Souldier.

A Table ſhewing the deminite parts vſed for menſuration.

FOraſmuch as ſome of theſe meaſures are to be vſed in the Treatiſe following, it is requiſite that I ſhew what kinde of meaſures are commonly vſed and now in force, beginning with a barly corne, frō whence all theſe hereunder and a great many moe doe proceed, as

An inch,		3 barley corns layed end to end.
a finger bredth,		4 barley cornes in thickneſſe.
a hand bredth,		4 fingers.
a foot,		12 inches.
a yard,		3 feet.
an ell,		5 quarters of a yard.
a ſpan,		3 handbredths.
a foot,		4 handbredths.
a geometricall pace,		5 feete.
a fadome,		6 feete, or 2 yards.
10 fadome,		a ſcore or 20 yards.
a furlong,	cōtaineth	125 paces.
our Engliſh furlong,		132 paces, or 660 feete.
a perch or rood,		5 yards $\frac{1}{2}$ or 16 feet $\frac{1}{2}$. (feet.
an aker,		160 perches, 528 paces, or 2640
a league, (mile		1500 paces.
an Italian or Engliſh		8 furlongs, or 1000 paces, or 5000
a Germane mile,		32 furlongs. (feet.
a ſcore,		20 yards.
an hundreth,		600 feet, after 5 ſcore to the 100.
24 grains of wheate		one penie of Troyes weight,
20 pence, (dry,		one ounce.
12 ounces,		one pound.
20 graines of barley,		one ſcruple of haberdepois weight
3 ſcruples,		one dramme.
8 drammes,		one ounce.
16 ounces,		one pound.
112 pound,		100 weight.
a tunne,		20 hundreth.

THE ARTE

A Table shewing how to weigh a great deale with few weights.

You may way any number of pounds from

- one to 40 with these 4 weights, 1. 3. 9. 27.
- 1 to 121 with these 5 weights, 1. 3. 9. 27. 81.
- 1 to 364 with these 6 weights, 1. 3. 9. 27. 81. 243.

This rule of weighing many things with few weights, proceedeth of Geometricall progreſſion. The pounds to be weighed, are wayed with as many namelike weights, to be done either double or three-fold, ſometime by adding one weight to another, and ſometimes by taking away and adding to the contrary ballance. Example in a double reſpect: All termes to 15 are weighed with 4 weights of pounds: as, 1.2.4.8. ſo in a triple reſpect, all pounds to 40 may be weighed with 4 weights, as 1.3.9.27. All pounds from 1 to 364 are to bee weighed with theſe 6 weights, 1.3.9.27.81.243. and ſo infinitely.

Mea-

Measures.

THe varietie of measures are in a manner infinite, and yet are all comprehended vnder three general kinds, proceeding from a point in Geometrie, as Arithmeticke doth from an vnite: that is to say, Lines, Superficies, Bodies.

Lines hauing but only length without bredth of thicknesse, doe measure onely Altitudes, Latitudes, and Longitudes, &c.

Superficies, being limited by lines, bearing length and bredth, without depth or thickneſſe: in theſe are knowne the contents of Pauements, Glaſſe, Boord, Land, &c.

Bodies, being bounden by Superficies, and containing length, bredth, and thicknes, doe make knowne the quantitie of all ſolide or maſſiue things, as timber, ſtone, &c. All which requires the ayde of Arithmeticke, to be truly meaſured. The definitions, termes, and orderly working of theſe and all other, the Elements of Geometrie will teach you.

Here I thought to haue written briefly, or rather to haue glaunced at the wonderfull ſtrange effects that Arithmeticke is able to worke and attaine to, but finding that that learned and famous man Maſter *Iohn Dee*, in his Mathematicall preface vpon *Euclids* Elements, doth notably touch the ſame, ſhewing the rare properties and incredible myſteries that numbers Art can reach to, affirming that the effects thereof, of man is not able fully to be declared, it ſoone ſtrake me in the dumps, feeling my ſelfe farre vnable to ſoare ſo high.

How to finde the cubicall radix or roote of any number.

AS in my booke of the Art of warre, entituled, Arithmeticall militarie concluſions, I began with the extraction of ſquare rootes, being a ſpeciall rule to worke diuers feats belonging to the ſaid Art: So in this Treatiſe I haue thought beſt to begin & ſhew how to extract Cubicke rootes, for that diuers concluſions are to bee done by the ſaid rule, in the worke following, letting paſſe all former rules, as leſſe neceſſarie, the which are commonly knowne to euery childe, that hath any ſight in the Art of numbring.

To finde the radix or roote cubicall of any number, you muſt note how many figures or numbers bee in the totall ſumme thereof, and then as is ſhewed in the rule how to extract the ſquare root of any number, you make a pricke or point vnder euery other number, beginning at the firſt number towards your right hand: euen ſo in this rule, in ſearching for the cubicall roote of any number, you muſt put a prick vnder the firſt number towards your right hand, and ſo increaſe your number of prickes, vnder euery third number, towards your left hand, and your quotient will containe ſo many figures as there be prickes.

If your number propounded bee cubicall, multiplie your quotient cubically, the product of that multiplication will be the number that was propounded.

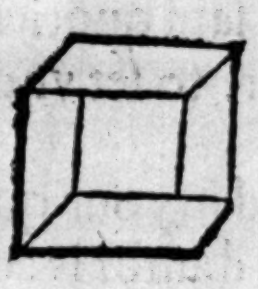
To multiply cubically, you muſt doe as this example ſheweth: 5 multiplied in himſelfe is 25, which 25 multiplied againe by 5, makes 125, and is a cubick number.

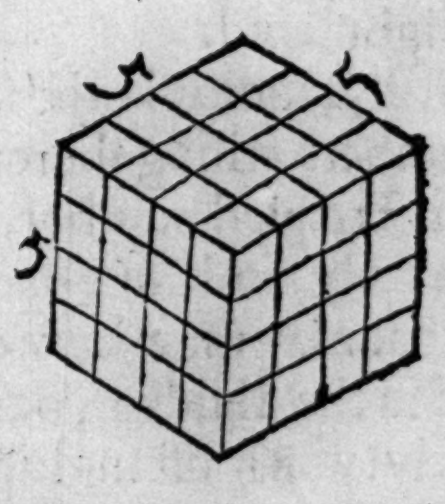
A cubiçall figure, is proportioned as theſe figures

ſheweth,

ſheweth, for a cube is a ſolide body of ſixe equal ſquares or ſides like a die,

Example.





It is requiſite in learning to extract rootes, to haue in perfect memorie all thoſe cubicke rootes of digit numbers, and the cubes they doe make, the which will bee a great helpe in working, the which I haue here ſet downe in a table after M. Records order.

1	1
2	8
3	27
4	64
5	125
6	216
7	343
8	512
9	729

Now to ſeeke for the firſt figure or roote, your table will ſhew you what number ſhall ſtand in the quotient, being due to the laſt pricke, towards your left hand, which figure ſo ſet in the quotient, multiplied cubickly, if it be equall to the number or numbers aboue that laſt pricke, it doth ſhew that the ſaid number or numbers are cubicke; but if it bee more than a cube number, then abate the greateſt cube number, that the quotient will make from the ſaid numbers, and cancelling the ſame, let the remaine ſtand ouer the head of the ſaid numbers,

as is done in diuiſion of common numbers, and ſo haue you done with the firſt pricke.

2 Secondly, triple your roote, ſetting the ſaid tripled number one place neerer from the laſt pricke, towards your right hand.

3 Thirdly, multiply the ſaid triple, by the ſaid quotient, the numbers ariſing thereof is your diuiſor, to ſet vnder your firſt tripled number.

4 Fourthly, find out a number to be placed in your quotient, that may ſhew how often times your diuiſor is contained in the diuident, or numbers ſo remaining ouer it.

5 Fiftly, you muſt multiply your diuiſor, by the number laſt placed in your quotient, firſt drawing a line vnder your diuiſor, and that which ariſeth of the ſaid multiplication muſt be placed vnder the ſaid line.

6 Sixtly, you muſt ſquare the number laſt placed in your quotient, and multiply the ſaid ſquare by the triple of your firſt quotient number, & the ſumme ariſing of that multiplication ſet vnder the line, one place neerer towards your right hand.

7 Seuenthly, multiply the number laſt placed in your quotient cubickly, and ſet the ſame cube numbers vnder the line, beneath the other numbers, one place neerer towards your right hand: and then drawing a line vnder the ſame, adde all thoſe numbers together; the ſumme ariſing abate from the other pricke that ſtands toward the right hand in your diuident, and if nothing remaine, the number propounded is a cubick number: but if any thing remaine, the number propounded is no cubicke number, but yet the quotient doth ſhew the neereſt cubicke roote in the propoſition.

In this order you muſt worke by euery prick, how many.

ny figures ſoeuer the numbers propounded containeth.

To finde a Denominator to the cubicke remaine.

If the number propounded be not cubicall, and that you deſire to know the true denominator to the cubicall remaine, you muſt ſquare your cubicke roote, and then triple the ſaid ſquare, and after triple the roote, adding all thoſe ſummes together, and to the totall of the ſaid addition, adde one vnite, ſo haue you the true denominator cubicall, the which you may abbreuiate into leſſer termes by Abbreuiation, according to your deſire.

Or you may finde the denominator cubicall, by multiplying the roote in the triple of another number that is more by one vnite nor the ſaid roote: and then adding one vnite to the product of the ſaid multiplication, you haue your deſire.

An example how to worke, to finde the cubicke roote.

Admit the ſumme or numbers, whoſe cubicke roote you deſire to know be 32768. I ſet the pricke vnder 8, & vnder the figure 2 ſtanding in the fourth place, as in the worke here you ſee, and I finde that the greateſt cubicke number in 32 is 27, and 3 is his roote, which 3 I place in the quotient, and his cube being 27, I ſubſtract from 32, ſo reſteth 5. And ſo I haue done with the firſt prick towards my left hand, as here in the work you may ſee.

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 05
32768(3
 27
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Then I triple the quotient 3, & it is 9, which I ſet one place from the laſt prick neerer towards my right hand.

And then I multiply the triple of the quotient being 9, by the ſaid quotient 3, ariſeth 27, the which I place vnder 57, drawing a line vnder my diuiſor 27, and then I ſeeke how oft I can haue 27 the diuiſor in 57, which is a part of the diuident, the which I can haue but 2 times : which 2, I place in the quotient, and by the ſaid 2 I multiply the diuiſor 27, ſo ariſeth 54, which I place vnder the line vnder the diuiſor, as here you ſee.

05
32768(32
9
27
54

And then I ſquare the number laſt placed in the quotient being 2, and it is 4, which ſquare I multiply by the triple of the firſt quotient number being 9, ariſeth 36, which I place vnder 54, one place neerer towards the right hand, as here you may ſee. And then multiplying the digit 2. cubickly ariſeth 8, to bee ſet vnder the line one place neerer towards the right hand, & adding all theſe ſums together, there ariſeth 5768, the which ſubſtracted frō the number belonging to the firſt prick there remaineth nothing : ſo I ſay that 32768 is a cubicke number, and 32 is the true roote thereof. You may proue it by multiplying the quotient cubickly, and abating the product from the number propounded, there will remaine nothing.

0
05000
32768(32
27
54
36
8
5768

To finde the neereſt root of a number not cubicke.

Queſtion.

I demand the true cubicke root of 117884.

Reſolution.

The pricks placed in order as before, I find there will be but

but 2 figures in the quotient, & that the cubick nũber of 117 is 64, whose cubick root is 4, which 4 I place in the quotient, and his cube 64 being abated from 117, there remaines 53 to be placed ouer the last prick: then tripling the quotiẽt 4, ariseth 12 to be set down one place neerer towards my right hand, & then multiplying the quotient by the said triple, doth arise 48 for a diuisor, which I set in his place, drawing a line vnder him as in the former work you see. And then I make search how oft I can haue 48 in 538, which I can haue many times, but more than 9 times I must not take; and therefore I set downe 9 in the quotient, & multiplying the same by the diuisor 48, ariseth 432, to be placed vnder the line vnder the diuisor, then I doe multiply the said 9 squarely, ariseth 81, the which multiplied by 12 being the triple of the first quotient, ariseth 972, the which I set downe one place neerer towards my right hand; and then I multiply 9 cubickly, ariseth 729 to bee set downe yet one place neerer towards my right hand: and adding all those sums together, the totall is 53649, which abated from 53884, rests 235. And thus I affirme, that 49 is the neerest cubicke root in whole numbers of 117884, as here by the worke you may see.

```
 00
 53(2(3(5
117884(49
-----------
 64
  12
  48
-----------
 432
  972
   729
-----------
 53649
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Now to finde a denominator for the 235 remaining, I square the roote 49, so ariseth 2401. Then I triple the said squared number, and there ariseth 7203, and then I triple the roote 49, ariseth 147, to which I adde one, and it makes 148. All which sums ioyned together, makes 7351, and so the true cubicke root of 117884 is 49 and $\frac{235}{7351}$ parts of an vnite.

Theormes ſhewing the true proportion that a bullet of one mettall beareth to the like bullet of a contrary mettall, as alſo the proportion that the circumference of any bullet or globe, &c. beareth to the diameter, and of the ſuperficiall content thereof to the diametrall ſquare thereof, the which according to *Archimedes* are thus proued.

All circles are equall to that right angled triangle, whoſe containing ſides, the one is equall to the ſemidiameter, the other to the circumference thereof.

The proportion of all circles to the ſquare of their Diameter, is as 11 to 14.

All globes beare together triple that proportion that their Diameters doe.

The circumference of any circle, is more nor the triple of his Diameter, by ſuch proportion as is leſſe than $\frac{1}{7}$ and more nor $\frac{10}{71}$.

A bullet of Iron, to the like bullet of marble ſtone is in proportion as 15 to 34.

A bullet of lead to the like bullet of Iron, is in proportion as 28 is to 19.

A bullet of lead to the like bullet of marble ſtone is in proportion as 4 to 1.

The Diameter of any bullet, &c. is in proportion to the circumference as 7 to 22.

How by knowing the true weight of any one bullet, and the diameter of the peece due for the ſaid bullet, to finde out the weight of any other bullet belonging to a contrarie peece of Ordinance.

Queſtion.

Admit a Demy Cannon of 7 inches Diameter ſhoot an

an Iron bullet of 32 pound weight, I demand what weight ſhall that bullet be of, that ſerues a Cannon of 9 inches diameter?

Reſolution.

To anſwer this and ſuch like, there is a generall rule; for *Euclid* in his ſixt booke of geometricall elements, hath demonſtrated and proued that all globes are in triple proportion to their Diameters, therefore I multiply the proportion of each bullet cubically, and I finde the cube of 7 is 343, and the cube of 9 is 729. Then by the rule of proportion I ſay, If 343 yeeld 32 pound weight, what ſhall that bullet weigh whoſe cube is 729? So multiplying 729 by 32 pound, the weight of the leſſer bullet, ariſeth 23328. which diuided by the 343, being the cube of the leſſer bullet, yeelds in the quotient 68 pound & $\frac{4}{343}$ parts of a pound, ſo much ſhall that bullet weigh, that ſerues a Cannon of 9 inches diameter, as by working the rule you ſhall finde.

Another eaſie concluſion, how by the weight of a ſmall bullet knowne, to finde out the weight of a greater.

Queſtion.

A bullet of 3 inches diameter weighing foure pound weight, what ſhall a bullet of the ſame mettall weigh whoſe diameter is twice the height of the former (that is 6 inches high?)

Reſolution.

I worke in the order of the former concluſion, multiplying the diameter of each bullet cubically, and diuiding as afore is ſhewed, the quotient is 32 pound weight, ſo much ſhall the greater bullet weigh.

In

Example.

In the laſt concluſion the weight of the greater bullet weighed 32 pound, being 6 inches diameter, how ſhall I finde the weight of a bullet of the ſame mettall that is but halfe that height.

Reſolution.

I finde the cube of 6 is 216, and the cube of 3 is 27, ſo framing the conuerſe rule of 3, I ſay: If 216 yeeld 32 pound weight, what will 27? And multiplying 27 by 32, and diuiding the product by 216, the quotient yeelds 4 pound, the true weight of the leſſer bullet. And note that if you know the diameter and weight of any bullet, and would know the weight of one that is but $\frac{1}{2}$ the height of the firſt, the leſſer ſhall be in weight but the $\frac{1}{8}$ part of the greater. Or knowing the weight of any bullet, if you would know the weight of another of the ſame mettall, being twice the height of the former, the greater ſhall weigh 8 times as much as the leſſer, as in a figure demonſtratiuely hereafter drawne you may ſee.

How by knowing the weight of any bullet whoſe diameter containeth both whole inches and parts of whole, how you ſhould worke to finde out the true weight of another whoſe diameter ends with a fraction.

Queſtion.

If a Sakeret ſhoote a bullet of 2 inches $\frac{1}{4}$ diameter, of 3 pound weight, what ſhall a Culuering ſhot weigh of 5 inches $\frac{1}{4}$ diameter?

Reſolution.

To anſwer this or ſuch like, I reduce each bullet into his

his proper fraction, and I finde that the bullet of 2 inches $\frac{3}{4}$ diameter will be in a fraction $\frac{11}{4}$ or a 11 quarters, & the Culuering bullet of 5 inches $\frac{1}{4}$ height, will be $\frac{21}{4}$; then I multiply each of theſe 2 fractions cubically, and I finde that the cube fraction of the leſſer bullet is $\frac{1331}{4}$ and the cubicke fraction of the greater is $\frac{9261}{4}$ which known, I ſet down vnder three pound (the weight of the leſſer bullet) the vnite 1, and it will repreſent a fraction thus $\frac{1}{1}$, and then multiplying and diuiding by the golden rule in fractions, I finde that the weight of the Culuering ſhot of 5 inches $\frac{1}{4}$ diameter will weigh 20 pound weight and almoſt $\frac{3}{4}$ pound, as in the working you may finde.

How by knowing the diameter and weight of an iron bullet, to finde the weight of a bullet of marble ſtone of the like diameter: or how by knowing the weight and height of a bullet of marble, to finde out the weight of an iron bullet of like height.

Queſtion.

Admit an iron bullet of 4 inches height weigh 9 pound, I demand what ſhall a bullet of marble ſtone weigh of like diameter.

Reſolution.

In a theoreme afore mentioned, I finde that a bullet of iron to the like bullet of marble ſtone, *ſhall* beare ſuch proportion as 34 is to 15. And therefore I multiply the weight of the iron bullet knowne being 9 pound by 15, (the proportion the ſtone bullet beareth thereto) ſo ariſeth 135, which diuided by 34, the quotient is 3 pound, and $\frac{33}{34}$ parts of a pound: that is, 4 pound wanting $\frac{1}{34}$ part of a pound, ſo much ſhall the bullet of marble ſtone weigh that is in Diameter and Circumference, equall to

the like bullet of iron. In like order reducing the weight of the ſtone bullet into his proper fractiō, you ſhal haue $\frac{295}{34}$ pound, which diuided by 15, the proportiō the ſtone bullet beareth to the like bullet of iron, your quotient is 9, the number of pounds that the irō bullet weigheth.

How by knowing the height aud weight of an iron bullet, to finde out the weight and height of the like bullet of lead, or how to finde the weight of an iron bullet, by knowing the weight of a leaden bullet of like diameter.

Queſtion.

There is a Cannon that ſhootes an iron bullet of 72 pound weight, what ſhall a bullet of lead of the ſame diameter weigh? *Reſolution.*

To worke this, I note that the theoreme before ſaith, that a bullet of iron to the like bullet of lead, ſhall beare ſuch proportion as 28 is to 19, therefore I multiply 72 (the pounds which the iron ſhot weigheth) by 28, ſo ariſeth 2016, which diuided by 19, the quotient is 106 pound $\frac{2}{19}$, ſo much will a leaden bullet weigh that is proportionall to an iron bullet of 72 pound weight.

In this order by working as I haue ſhewed in the end of the laſt concluſion, you may by knowing the weight of the leaden bullet, finde out the weight of the like bullet of iron.

How you may find out the weight of any ſtone bullet of marble, by knowing the weight of the like bullet of lead, or how by knowing the weight of the ſtone bullet to finde out the weight of a leaden bullet of like proportion.

Queſtion.

If a bullet of lead weigh 106 pound, what ſhall a bullet

let of marble ſtone weigh of the ſelfe like proportion?

Reſolution.

To anſwer this, I finde that a bullet of lead to the like bullet of marble, beareth ſuch proportion as 4 to 1. Therfore multiplying 106 by 1, and diuiding the product by 4, the quotient will be 26 pound & $\frac{1}{2}$, ſhewing the true weight of a ſtone bullet, that is proportionall to the like bullet of lead.

And now to finde out the weight of the leaden ſhot, by knowing the weight of the ſtone ſhot, reduce the ſtone bullet into his proper fraction, you ſhall haue $\frac{53}{2}$, & ſetting 1 vnder 4 fraction wiſe, multiply the numerators together, and likewiſe the denominators, and diuiding the product ariſing of the numerators by the product of the denominators, your quotient will bee 106 pound, ſhewing the true weight of the leaden bullet.

If you haue or doe know the weight and true height of a bullet of ſtone, or any other mettall, & are deſirous to know the weight and height of another bullet that is greater or leſſer, and of the ſame mettall, in working as the firſt concluſion ſheweth, you ſhall haue your deſire.

To finde out the circumference of any circle or bullet.

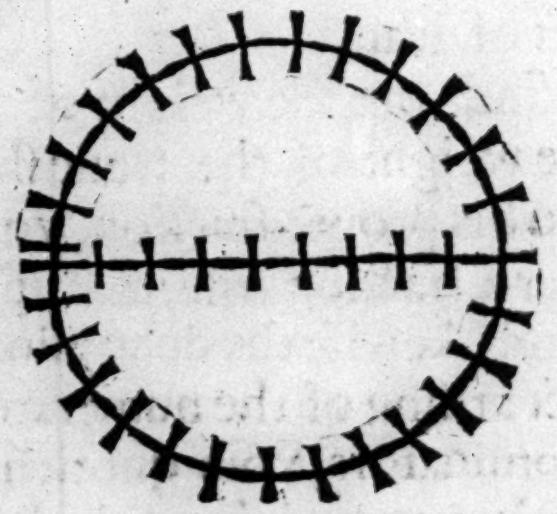
Queſtion.

I demand how many inches is about the circumference of that bullet whoſe diameter is 9 inches.

Reſolution.

To work this or any ſuch like, there is a general rule, as thus, that the proportion of the diameter to the circum-

ference is as 7 to 22, therefore multiplying the diameter 9 by 22 ariſeth 198, which ſumme diuided by 7, the quotient is 28, $\frac{2}{7}$ ſhewing the true number of inches about the circumference of a bullet of 9 inches diameter, as the figure here demonſtrated ſheweth.



How you may by knowing the circumference of any bullet, finde out the height or diameter of the ſame.

Queſtion.

The circumference of the bullet in the laſt concluſion, contained 28 inches $\frac{2}{7}$ as in the demonſtration you may ſee, I would know how I ſhould worke to finde how many inches the diameter of the ſame is.

Reſolution.

To worke this and all ſuch like, I muſt worke contrarie to the former concluſion, firſt reducing the whole number and broken, being 28 inches $\frac{2}{7}$ into his proper fraction, and it will be $\frac{198}{7}$ then multiplying by 7 according to *Archimedes* doctrine, and diuiding by 22, the quotient will be 9, ſo many inches is the diameter of the ſame bullet.

In

In this order you may finde out the diameter and circumference of all other bullets.

How to finde out the ſolid content of any bullet, &c.

Queſtion.

There is a bullet of iron whoſe diameter containeth 9 inches, how many ſquare inches is in the ſolid content thereof?

Reſolution.

To know this and all ſuch like, there is a generall rule, as thus, to multiply the diameter in his ſquare, I meane cubically, and then multiply that product by 11, diuide the totall ſumme by 21, the quotient ſheweth the number of ſquare inches in that ſpherical globe or bullet, for 9 multiplied cubically ariſeth 729, which augmented in 11 is 8019, that totall diuided by 21, yeeldeth 381 inches, and $\frac{6}{7}$ ſo many ſquare inches of iron will be in a bullet of 9 inches diameter.

To finde the true content of the ſuperficies of any circle drawne vpon a flat, as on a table or paper, &c.

Queſtion.

There is a circle whoſe diameter is 21 inches, I demand how many ſquare inches is contained within the circumference of the ſame?

Reſolution.

To reſolue this or ſuch like, there is a generall rule, in taking $\frac{1}{2}$ the diameter, and multiplying it in $\frac{3}{7}$ the circumference, or ſquaring the diameter, and multiplying the product by 11, and diuiding the reſult by 14, the

quotient ſheweth the Area or content of all the ſuperficies within the circumference thereof. *Example:*

The ſqnare of 21 is 441, which multiplied by 11 is 4851, that diuided by 14, yeeldeth in the quotient 346 inches $\frac{1}{2}$. Or other waies, take the halfe of 21 inches, that is, 10 inches $\frac{1}{2}$, & take $\frac{1}{2}$ of the circumference, which is 33 inches, reduce them into fractions according to the rule, you haue $\frac{21}{2}$ for the diameter & $\frac{33}{1}$ for the circumference, then multiplying the one by the other, the product is $\frac{693}{4}$, which diuided by the denominator 2, yeeldeth in the quotient $346\frac{1}{2}$ as before. In this order you may find out the content of the plaine of any circle.

To finde out the circumference of any bullet or globe diuers and ſundrie waies.

Queſtion.

How many inches is about the circumference of that bullet or globe, whoſe diameter is ſuppoſed to be 21 inches high?

Reſolution.

After you haue with your callapar compaſſes, found out the height of the diameter, multiply the ſame by 22, ſo there will ariſe 462, the which diuided by 7, the quotient will be 66 inches, the true meaſure of the circumference.

Another way.

Triple your diameter, and thereto adde the $\frac{1}{7}$ part of the ſame, your product is the circumference. *Example:*

The triple 21 is 63, and the $\frac{1}{7}$ part of 21 is 3, which added to 63 is 66 inches, as before.

Another way to worke the ſame.

Looke how many times you can haue 7 in the diameter, ſo many times muſt you haue 22 in the circumference. *Example.* The diameter being 21 inches, diuided by 7, yeelds in the quotient 3, by which if you multiply

22

22, your product will be 66 inches, for the circumference, as before. In this order you may find out the circumference of any bullet, or ſpherical body, &c.

To finde out the ſuperficies of any round body, as bullet, globe, &c. diuers and ſundry waies.

Queſtion. I haue a demy Cannon bullet of 7 inches diameter, I demand how many inches the ſuperficiall content thereof is?

Reſolution. To anſwer this and all ſuch like, I muſt in the order before ſhewed, find out the circumference of the bullet, and I finde that a bullet of 7 inches diameter, ſhall containe 22 inches in circumference, which circumference being multiplied in the diameter, ariſeth 154 inches, the true number of inches contained vpon the ſuperficies of a bullet of 7 inches diameter.

Another way.

Multiply the ſquare of the diameter of any bullet or globe by $\frac{22}{7}$ the product is your deſire. *Example:* The bullet whoſe diameter was 7 inches being ſquared, the ſquare thereof is 49, which multiplied by 22, yeeldes 1078, which ſum diuided by 7, the quotient is 154 inches as before. *Another way.*

Diuide the ſquare of the circumference of any bullet by $\frac{22}{7}$ your quotient numbers will ſhew you the ſuperficiall meaſure of the ſame. *Example.*

The circumference of the bullet aforenamed of 7 inches diameter containeth 22 inches, the ſquare thereof is 484 inches, that nũber diuided by $\frac{22}{7}$ as you do in fractions, in ſetting an vnite vnder the ſquare number thus, $\frac{484}{1}$ & multiplying the ſaid ſquare number by the denominator of the other fraction being 7, ariſeth 3388, which diuided by the numerator 22, the quotient

is

is 154 inches, the ſuperficiall content thereof, as before.

How you may finde out the ſolid content or craſsitude of any round bullet or globe, &c. diuers wayes.

Queſtion.

In the queſtion before propounded of the bullet, whoſe diameter was 21 inches, I would know how many inches be in all the ſolid or maſſiue content therof?

Reſolution.

I multiply the diameter cubickly, and after multipliing that cubicke number by 11, ariſeth 101871, the which diuided by 21, my quotient is 4851, ſhewing there is ſo many inches in the ſolid content of a bullet or globe of 21 inches diameter.

Another way.

Multiply the cube of $\frac{1}{2}$ the circumference by 49, and diuide the product ariſing thereof, by 363, your quotient will ſhew your deſire. *Example:* The circumference of a bullet whoſe diameter is 21 inches, containeth 66 inches, the $\frac{1}{2}$ thereof is 33 inches, the cube whereof is 35937, that ſumme multiplied by 49 is 1760913, which diuided by 363, the quotient is 4851 inches as before.

How you may by knowing the diameter and weight of any bullet, or other round body, finde out the diameter of any bullet or globe that weigheth twice the weight of the former.

Queſtion.

There is a demy Culuering bullet of 4 inches diameter weighing 9 pound, I demand the true height of that

that bullet which weigheth 18 pound weight.

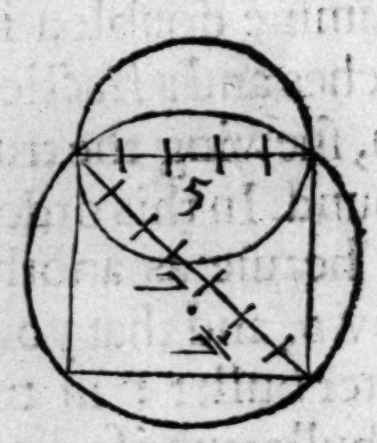
Resolution.

To worke this and all such like demands, this rule is generall in multiplying the height of the lesser bullet whose weight is knowne cubically, then doubling that summe, and extracting the cubicke roote thereof, the quotient will answer your question. *Example.* The bullet afore named of 4 inches diameter being multiplied cubically is 64, that summe doubled is 128, the cubicke roote thereof is 5 inches and a fraction remaining scarce the $\frac{1}{30}$ part of an inch, shewing the true height of a bullet that weigheth 18 pound. In this order if you haue a bullet that is 3 times as heauie as another of like mettall, whose weight is known, and that you desire to know the diameter of the greater bullet: in tripling the cubicke number of the lesser bullet whose diameter is knowne, & extracting the cubicke roote thereof, you shall finde out the true height of the greater bullet. Or if you would find out the height of any bullet of like mettal, that weigheth 4 times as much as an other bullet whose weight is knowne, quatriple the cubicke number of the diameter of the lesser bullet, and extract the cubicke root thereof, your quotient will satisfie you. Or if 5 or 6 times, &c. in working as I haue shewed you may finde your request.

How you may Geometrically finde out the diameter of any bullet, that weigheth twice as much as another knowne bullet.

Take the true height or diameter of the lesser bullet whose weight you know, and square the same as you see in the figure following. Then draw a line that may diuide

the ſaid ſquare in 2 equall parts, in the 2 oppoſite angles, and that line ſhall be the diameter of a bullet twice the weight of the other: then diuide that diametrall line in 2 equall parts, ſetting one foot of your compaſſe in the center or mids thereof, and with the other foot draw a circle, and that circumference will repreſent the proportion of a bullet, twice as much in weight as the leſſer.



How you may Arithmetically proue this concluſion.

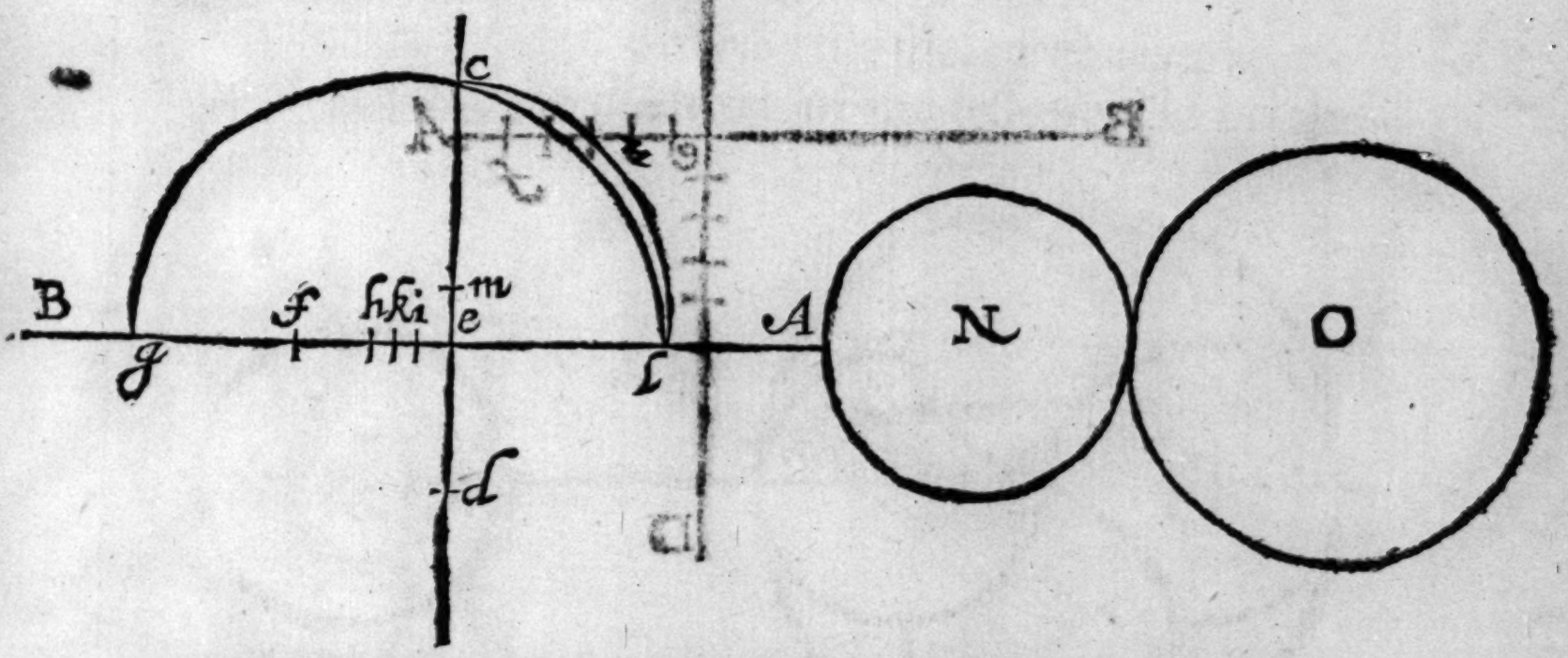
The diameter of the leſſer bullet is 5 inches, the ſquare of it is 25. that ſum double is 50. the ſquare roote of 50, is 7.$\frac{1}{7}$ and ſo much is the diameter of the greater bullet, as in the figure here drawne you may ſee.

Another way Geometrically, to finde the diameter of any vnknowne bullet that is double the weight of a knowne bullet.

Draw a ſtraight line of what length you thinke good, as you ſee the line A. B. then draw another croſſe line perpendicular to the ground line as you ſee the line C. D. note the meeting or croſſing of the lines, as is the point E. This done, open your compaſſe the iuſt length

of

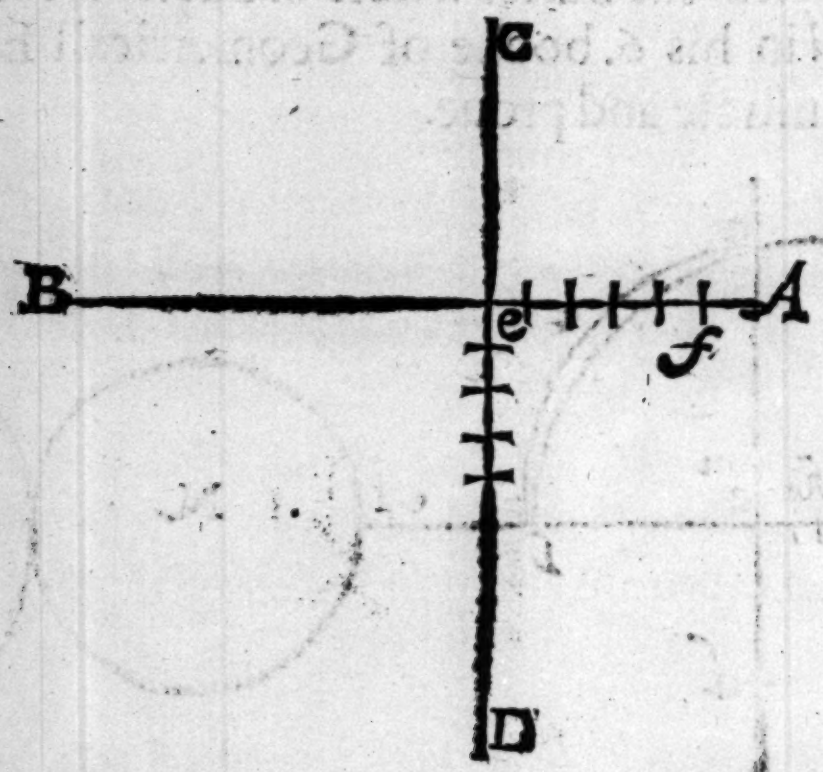
of the diameter of the leſſer bullet whoſe weight you would double, ſetting one foot of the compaſſe in E. and the other in D. and meaſure towards B. twice that diameter, as is done in the points F. G. Then diuide the line E. F. in 2. equall parts in the point H. and after diuide the line E. H. in 2 equall halfes, as in the point I. And laſtly diuide the line I. H, in 2 equall parts in the point K. Which done, open your compas, placing one foot in K. and the other in G. draw ½ a circle, as you ſee, I dee the ſemicircle L. C. G. After diuide the line C. D. in 2 equall parts in the point M. and opening your compaſſe the iuſt widenes of one of thoſe parts, ſet one foot in M. and with the other foot draw the line C. N. L. Which done, the bullet whoſe diameter is the line L. E. will weigh twice as much as the bullet whoſe diameter is the line E. D. as *Euclid* in his 6. booke of Geometricall Elements doth demonſtrate and proue.



The greater circle O. doth ſhew the proportion of a bullet that weigheth twice as much as the leſſer circle N. both the ſaid bullets being caſt of one like mettall.

Another demonſtration to proue the former concluſion by numbers.

In a concluſion before ſet downe, where the bullet of a demy Culuering of 4 inches diameter weighed 9 pound, I proued that a bullet whoſe weight was 18 pound ſhould be more than 5 inches diameter. Euen ſo I haue hereunder diuided the line E.D. of the former concluſion, being ſuppoſed to bee the diameter of a bullet whoſe weight is knowne, into 4 equall parts or inches. And likewiſe diuiding the Diameter F. E. into the like diuiſions it containeth 5 of thoſe parts, and almoſt the $\frac{1}{30}$ part of an inch more, ſhewing the true height of a bullet that is twice as much in weight as the leſſer bullet of 4 inches diameter, as this figure ſheweth.



As the vpper face or ſide of any ſquare being doubled, the ſquare ariſing of that doubled ſide ſhall be in proportion iuſt 4 times as much as the firſt ſquare was, whereas a great

a great many would think it would be but twice as much. Euen ſo the diameter of any circle being doubled, the Area or ſuperficiall content of the flat of the ſame circle ſo doubled, ſhall be foure times as much as the other. Alſo any cube, globe or bullet, whoſe diameter is in double proportion to another, the ſolide content of that bullet whoſe diameter is ſo doubled, ſhall be in weight 8 times as much as the leſſer, as theſe two examples in the concluſions following figuratiuely drawne, ſheweth.

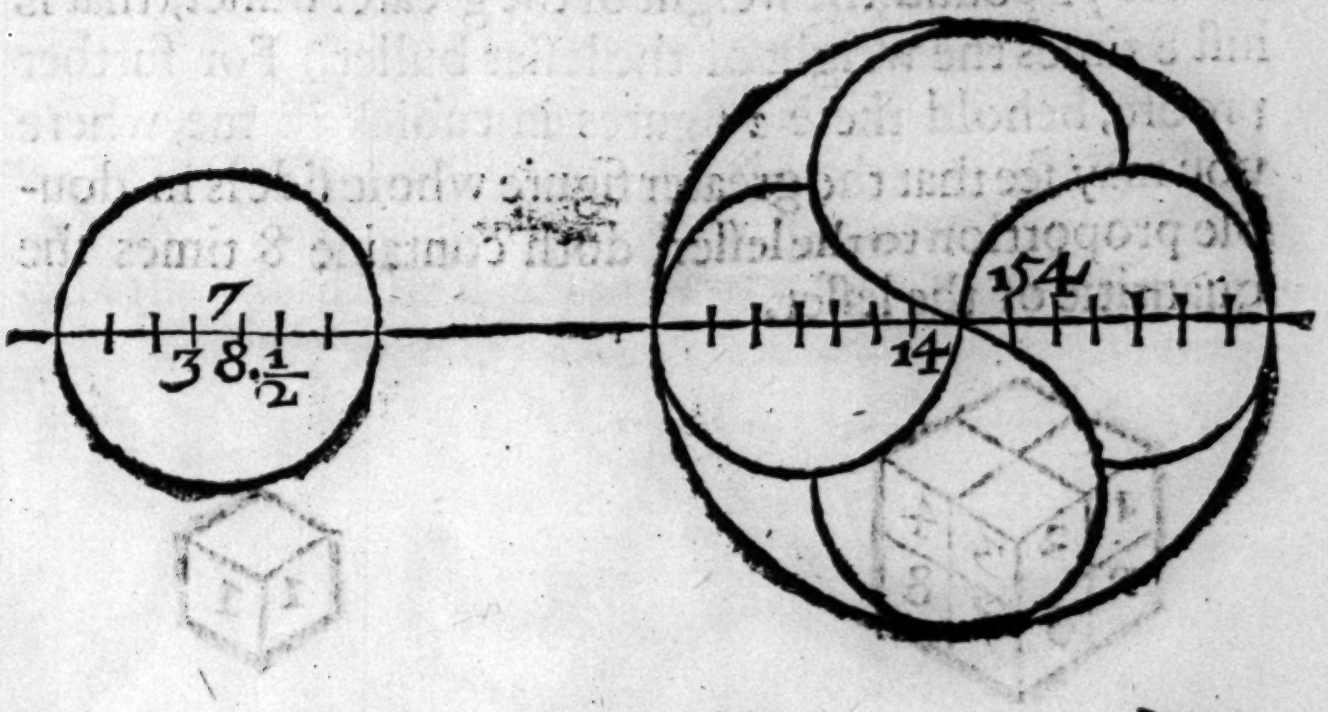
How by knowing the ſuperficiall content of the plaine of any circle, to finde out the ſuperficiall content of another that is twice the diameter of the firſt.

Queſtion.

There be two circles drawne, the one 7 inches diameter, the other 14 inches: how much is the content of the greater circle more than the leſſer?

Reſolution.

To anſwer this or the like, by the theoreme afore mentioned, I ſquare the diameter of the leſſer circle being



ſeuen inches, ſo ariſeth 49 inches, that ſquare multiplied by 11, yeelds 539, the which diuided by 14, the quotient is 38 inches $\frac{1}{2}$ ſhewing the ſuperficiall content of the circle of 7 inches diameter. Alſo working in the ſame order, I finde the content of the greater circle of 14 inches diameter to containe 154 inches, which diuided by 38. $\frac{1}{2}$ the quotient is 4, ſhewing that the ſuperficiall content of the greater circle is iuſt 4 times as much as the leſſer.

By knowing the weight and height of any one bullet to finde out the weight of another of twice the height of the former.

Queſtion.

If a bullet of 4 inches diameter weigh 9 pound, how much ſhall a bullet of 8 inches height weigh.

Reſolution.

To know this or the like, multiply the diameter of each bullet cubically, & I finde the cube of 4 is 64, & the cube of 8 is 512, which knowne, I frame the rule of proportion, ſaying, If 64 yeeld 9 pound, what will 512? and in multiplying and diuiding according to the rule, my quotient is 72 pound, the weight of the greater bullet, (that is iuſt 8 times the weight of the leſſer bullet.) For further proofe, behold theſe 2 figures in cubick forme, where you may ſee that the greater figure whoſe ſide is in double proportion to the leſſer, doth containe 8 times the quantitie of the leſſer.

An

An easie rule to finde out the diameter of any bullet, and how to know how much one bullet is higher than another by Arithmeticke skill, without any callaper compasses.

If you want a paire of callaper compasses, take a line or a garter, &c. and gird the bullet or bullets whose height you desire iust in the mids, laying that measure to an inch rule, noting how many inches or other measure the same containeth, then multiplying the said measures by 7, and diuiding by 22, the quotient will shew you your request. And then abating the lesser diameter from the greater, the remaine will shew you how much the one is higher than the other.

Example.

Suppose the circumference of the one bullet be 16 inches, and the circumference of the other 26 inches, in working as aboue is taught, I finde the diameter of the lesser bullet is 5 inches $\frac{1}{11}$ and the diameter of the greater bullet 8 inches $\frac{4}{11}$, so abating the lesser from the greater, the remaine is 3 inches and $\frac{3}{11}$ parts of an inch, shewing the greater bullet is so much in height more than the lesser. The like is to be obserued with any other.

By this rule you may know how much the circumference or any part of your peece is higher than another.

A Table shewing the weight of all Iron bullets from the Fawconet to the Cannon in Habberdepoiz weight.

Height of the shot in inches and parts of inches.		Weight of the shot in pounds and parts of pounds.	
Height.		Weight.	
2.		1.	2/7
2.	1/4	1.	3/4
2.	1/3	2.	1/3
2.	3/4	3.	3/7
3.		4.	1/2
3.	1/4	5.	
3.	1/2	6.	2/9
3.	3/4	7.	6/7
4.		9.	
4.	1/4	10.	3/4
4.	1/2	12.	2/3
4.	3/4	14.	5/8
5.		16.	1/4

Height of the shot in inches and parts of inches.		Weight of the shot in pounds and parts of pounds.	
Height.		Weight.	
5.	1/4	19.	2/3
5.	1/2	22.	1/7
5.	3/4	25.	5/9
6.		29.	1/2
6.	1/4	32.	1/8
6.	1/2	36.	5/8
6.	3/4	40.	3/4
7.		46.	
7.	1/4	52.	6/7
7.	1/2	56.	5/8
7.	3/4	64.	1/2
8.		70.	
8.	1/4	76.	2/3

How you may Arithmetically know the true breadth of the plate of the ladle that is due for any peece of Ordinance, by knowing the height of the bullet fit for the ſaid peece.

Take a line and compaſſe the bullet in the mids, laying the ſame meaſure to an inch rule, diuide the ſame meaſure into 5 equall parts, 3 of thoſe parts is the iuſt bredth you ought to make your plate of, which being orderly placed on the ſtaffe, and bent circularly, ſerues to hold the powder in: the other $\frac{2}{5}$ parts being cut and taken away, and ſo left open, ſerues to turne the powder into the peece, the which to doe Gunner-like, as ſoone as you haue filled the ladle ſo full that you may ſtrike the ſame with a rule, and put the ſame into the mouth of the peece, fixe your thombe vpon the vpper part of the ſtaffe, towards the end next the tampion or head thereof, and ſo thruſting the ladle gentlie home to the breech of the peece, turne the rammer ſtaffe, ſo as your thombe fall directly vnder the ſtaffe, and ſo ſhall you empty your ladle orderly.

Now to know the $\frac{3}{5}$ parts of the bullets circumference, that you may make the plate of your ladle orderly, & of that iuſt breadth, lay the meaſure of the whole circumference to an inch rule, and then multiply the ſame by 3, and diuide the product by the denominator 5, your quotient will tell you truely the breadth that the plate of your ladle ought to be of.

Example.

A Cannon whoſe bullet is 7 inches high, will be 22

inches in the circumference, that multiplyed by 3 is 66, which diuided by 5, the quotient is 13 inches $\frac{1}{5}$, the true breadth that the plate for a cannon ladle of 7 inches diameter ought to be of.

The length of the ladle is to be made according to the length, height, and weight of the peece for which it is made, which in a table in the end of the booke you may finde set downe for all sorts of peeces.

How to make a ladle for a chamber-bored peece.

Open your compasse the iust diameter of the chamber, within $\frac{1}{8}$ part of an inch thereof. Diuide that measure in 2 equall parts, then set your compasse to one of those parts, and with the one foote fixed on a paper or smooth boord, draw with the other foot a circle; the diameter thereof will be a iust quarter of an inch shorter than the diameter of the chamber-bore, by the circumference wherof, you may finde out the true breadth of the plate of a ladle that is fit for such a chamber-bored Cannon, by the rule afore set downe how to finde the true breadth of the plate of any ladle, for any other peece of Ordinance, in taking the $\frac{3}{7}$ parts of the circumference thereof, the length ought to be twice the diameter, and $\frac{2}{5}$ parts, to hold at 2 times the iust quantitie of corne powder that is due to charge such a chamber-bored cannon with.

Example.

The diameter of the circle drawne for any cannon whose chamber-bore is 7 inches, containeth 6 inches $\frac{3}{49}$, the circumference whereof is 21 inches $\frac{6}{7}$, the $\frac{3}{7}$ parts thereof is 12 inches $\frac{1}{7}$, and so much ought that ladle to bee

be in breadth, and in length it ought to be 18 inches $\frac{2}{3}$. In this order you may worke to make a ladle in length and breadth for any bel-bored Cannon: and to finde out the thickneſſe of the mettall at the touch-hole, or the height of the bore thereof, the concluſion following will ſhew you.

How to finde out the height or diameter of the chamber, in any chamber-bored Cannon, or other peece of Ordinance, and how to finde out the thickneſſe of the mettall round about the chamber thereof.

Take your priming Iron, or elſe a ſtraight peece of wyer, and bow the end thereof in manner of a hook, and then put the ſame into the touch-hole, downe to the loweſt part of the concauity of the peece, and then with your knife or elſe with a peece of chalke, make a ſtroke vpon the wyer hard by the vpper part of the mettal, without the peece at the touch-hole, then meaſure by your inch rule, how long the wyer is from that ſtroke to the end. After put in the ſame wyer againe, and pull it vp, ſo as the bowed end may reſt or ſtay within the cilinder or concaue of the peece: and make another marke or ſtroke on the ſaid wyer, hard by the vpper part of the mettal; the diſtance betweene thoſe 2 ſtrokes, is the iuſt thickneſſe of the mettall, round about the chamber, the which abated from the length of the wyer (I meane from the firſt ſtroke to the loweſt end) the remaine is the true diameter of the chamber-bore in that peece.

Example.

Admit the length of the wyer from the end of the con-

cauity to the firſt ſtroke containeth 15 inches, and the diſtance betweene the 2 ſtrokes is 8 inches: then thoſe 8 inches is the iuſt thickneſſe of the mettall about the chamber; which abated from 15 inches, reſtes 7 inches, the iuſt diameter of the chamber in ſuch a peece.

By Arithmeticke skill, how to know whether the caryage for your peece be truly made or no: or how the caryage for any other peece of Ordinance ought to be made.

Meaſure the iuſt length of the Cilinder or bore of your peece, the plankes of your caryage ought to bee once and a halfe that length. Alſo meaſure the diameter of the peece, and the ſaid plankes at the fore end ſhould bee in depth 4 times the diameter, and in the midſt 3 times and $\frac{1}{2}$ the diameter, and at the end next the ground, two times and $\frac{1}{2}$ the diameter, and in thickneſſe once the diameter.

Example.

Admit a Culuering of ſixe inches diameter is in length in the bore thereof 20 times that meaſure (that is, 10 foote long,) then I ſay that the plankes of her caryage ought to bee 15 foote in length; and at the fore end next the peece 2 foote in breadth, and in the midſt one foote three quarters, and at the loweſt end next the ground one foote and a quarter: and in thickneſſe halfe a foote. Alſo euery caryage ought to haue foure tranſomes, and ought to be ſtrengthened with ſtrong Iron bolts.

The

The holes or centers wherein the trunions ought to lye, ought to be three times and ½ the diameter from the fore end of the caryage, and in depth ⅔ parts of the thickneſſe of the trunions, which depth you may eaſily finde out, as thus: take the height or diameter of the trunions, and multiply the ſame meaſure by 2, and diuiding by the denominator 3, the quotient will ſhew your deſire.

How by knowing the weight of any one peece of Ordinance, to finde out the weight of any other.

Queſtion.

If a Saker of foure inches diameter weigh 1600 pound weight, what will a Culuering weigh that is ſixe inches diameter?

Reſolution.

Some would thinke that the rule of proportion plainly wrought, would anſwer this queſtion: but in that they are deceiued; for the content of ſolide bodyes being maſſie, are Sphericall or Cubicall in proportion, therefore you muſt multiply the diameters of euery peece cubically, & ſet downe the weight of the peece knowne in the middle number, and ſo working according to the rule of proportion, you ſhall finde out the true weight of the greater peece.

Example.

4 inches the diameter of the leſſer peece, multiplied cubically, ariſeth 64 inches. Likewiſe the cubicke num-

ber of the diameter of a Culuering of 6 inches high, is 216 inches: then framing the rule of proportion, I say, If 64 being the cube of 4 yeeld 1600 pound weight, (being the weight of a Saker of 4 inches bore) what will 216 being the cubicke number of 6 inches, so multiplying 216 by 1600, ariseth 345600. which diuided by 64 yeeldes in the quotient 5400 pound weight, so much weigheth the Culuering of 6 inches diameter.

In working by the conuerse rule of proportion, you may not onely prooue this conclusion, but also may find out the weight of any lesser peece of Ordinance, by knowing the weight of a greater.

Example.

If 216 being the cube of 6 inches, yeeld 5400 pound in weight, what will 64 being the cube of 4 inches? so multiplying 5400 by 64 there ariseth 345600. which diuided by 216, the quotient is 1600 pound weight, shewing the true weight of the Saker of 4 inches diameter, as before.

Or if the diameters of the peeces whose weight you would know, containe both whole numbers and broken, in reducing each diameter into his proper fraction, and multiplying the same cubically, setting down the weight of the peece knowne, in the middle place, for the second number, and multiplying and diuiding as afore is taught, the quotient will shew you your request, as the conclusion following will teach you.

Question.

If a demy Culuering of 5 inches $\frac{1}{4}$ diameter weigh 2600 pound weight, what will a Cannon of 7 inches $\frac{3}{4}$ diameter?

Resolu-

Resolution.

I reduce the diameter of each peece into his proper fraction, and I finde that the broken number of 5 inches $\frac{1}{4}$ diameter containeth $\frac{21}{4}$ which multiplied cubically ariseth $\frac{9261}{4}$. Likewise I reduce the diameter of the Cannon, being 7 inches $\frac{3}{4}$ into his fraction, and it is $\frac{31}{4}$, whose cube is $\frac{29791}{4}$: then I set an vnite 1 vnder 2600, and it doth represent a fraction thus $\frac{2600}{1}$. Now to finde out the weight of the greater peece, I set down these 3 new made fractions in the order of whole numbers, and working by the rule of proportion, I finde the greater peece weigheth 8363 pound, and almost $\frac{1}{4}$ of a pound: for in multiplying 29791 by 2600, there ariseth 77456600, the which augmented by the denominator 4, maketh 309826400 for the diuident or number to be diuided. Likewise the fraction of the lesser peece being 9261, multiplyed by his denominator 4, makes 37044 for a diuisor, which diuident being diuided by the diuisor, yeeldeth in the quotient 8363 pound, and certaine parts of a pound, so much will a Cannon of 7 inches $\frac{3}{4}$ weigh being proportionall in mettall to the other peece.

How you may by Arithmeticall skill, know how much of euery kinde of mettall any brasse peece of Ordinance containeth.

Question.

Euery Gun-founder doth commonly vse for euery 100 pound weight of copper, to put in 10 pound weight of Lattin, and 8 pound weight of pure Tinne: I demand how many pound weight of euery of those mettals is in

in a Culuering of 5600 pound weight?

Reſolution.

To anſwer this or all ſuch like, I ioyne all the ſeuerall mixtures together, and they make 118 pound, which I reſerue for my diuiſor. Then I multiply the weight of the peece by euery mixture ſeuerally, and there ariſeth of the 100 weight of copper being the greateſt mixture, 560000, the which ſum is to be diuided by the diuiſor common (to wit, 118 pound) and the quotient is 4745 pound and $\frac{90}{118}$ parts of a pound: ſo much copper is in the ſaid peece. Now to know how much latin is in the ſame, I multiply the whole weight of the peece by 10. the ſecond mixture, and the product is 56000. which number diuided by the diuiſor common, the quotient is 474 pound $\frac{68}{118}$: ſo much latin is in the ſame peece. And laſtly to know how much Tin was in the ſame peece, I multiply the weight of the peece by 8, ariſeth 44800, which diuided by the diuiſor 118, the quotient is 379 $\frac{78}{118}$: and ſo much Tin was put into the ſaid peece.

Now to proue the worke if it bee truely wrought or not, I adde all the 3 quotients together, and becauſe they doe all make the true ſum of the whole weight of the peece according to the propoſition, I affirme the ſame to be truely wrought.

Note. The Gun-founders doe hold and affirme, that the Lattin doth incorporate, and cauſeth the peece to bee of a good colour, and the Tin doth ſtrengthen and binde the other mixtures.

How you may know how far any peece of Artillery wil conuey her bullet at the beſt of the randon, by knowing the vtmoſt range and point blancke of another peece, and how to proue the ſame: by which rule, you may know how far any peece will reach at point blancke and vtmoſt range.

Queſtion.

If a Saker at point blanke conuey her bullet 200 paces, and at the beſt of the randon ſhoot 900 paces, what will that Cannon do which at point blancke ſhoots 360 paces?

Reſolution.

To reſolue this or the like, I ſet downe the numbers proportional according to the rule, multiplying 900 paces (the vtmoſt randon of the Saker) by 360 paces, (the point blanke of the Cannon,) ſo ariſeth 324000, which diuided by 200 the number of paces the Saker ſhoots at point blanke, the quotient is 1620. And ſo many paces will a Cannon ſhoot at the beſt of the randon, that at point blanke rangeth 360 paces, as by working you may finde, and by experience better vnderſtand.

You may proue this concluſion by the conuerſe rule of proportion, multiplying 900 the number of paces the Saker ſhoots at the beſt of the randon, by 360, the paces that the Cannon ſhoots at point blancke; and diuiding that product 1620 the number of paces the Cannon ſhoots at the beſt of the randon, the quotient is 200, ſhewing the number of paces that the Saker ſhall ſhoot at point blanke. In this order you may worke the like concluſion by any other peece of Artillery, and find out the point blanke and vtmoſt range thereof.

To know how much a bullet of yron will out flie a bullet of lead of the like diameter, being both discharged out of one peece, with one like quantitie in powder.

Queſtion.

If a bullet of lead of 24 pound weight, being ſhot out of a peece with $\frac{2}{3}$ parts of the ſaid bullets weight in powder, range at point blanke 240 paces, how farre will a bullet of yron of like height range, being diſcharged out of the ſaid peece at point blanke with the like qnantitie of powder?

Reſolution.

The proportion betweene a bullet of yron and a bullet of lead of the ſame height, I haue ſhewed by the theoremes and concluſions afore ſet downe: by which I finde that a bullet of yron being of equall diameter to a leaden bullet of 24 pound weight, the ſaid yron bullet ſhall weigh 16 pound $\frac{2}{7}$ parts. And for as much as the leaden bullet is ſhot with $\frac{2}{3}$ parts in powder of his weight, that is, with 16 pound of powder, which is very neare the full weight of the yron bullet, I finde that the ſaid bullet of yron ſhall out flie the leaden bullet $\frac{1}{7}$ part of the leuell range (that is) the yron bullet ſhall flie being ſhot as afore at point blanke 320 paces, that is, 80 paces further than the leaden bullet rangeth at point blanke. But if the peece out of which the ſaid bullets were ſhot, had beene mounted at any number of degrees of randon, the range of the yron bullet would ſhorten ſomewhat of the $\frac{1}{7}$ of the ouerplus of the ſaid range: ſo that if the peece were mounted to the beſt of the randon, the ſaid bullet of yron would not out flie the leaden bullet, not the $\frac{1}{7}$ part of the ſaid range.

By knowing how much powder is ſufficient to charge any one peece of Ordinance, to know how much of the ſame powder will charge any other peece of Ordinance

Queſtion.

If a Saker of 4 inches diameter, require 5 pound of corne powder for her due loading, how much of the ſame like powder will charge a Cannon of 7 inches diameter?

Reſolution.

The plaine rule of proportion cannot reſolue this concluſion, except you multiply euery number cubically, and then the quotient will ſhew you your deſire.

Example.

The cube of 4 is 64, and the cube of 7 is 343, which multiplied by the weight of the charge of powder due to load the leſſer peece, ariſeth 1615, which diuided by the cubicke number of the diameter of the leſſer peece, yeeldes in the quotient 25 pound and almoſt $\frac{1}{4}$ part of a pound: ſo much corne powder muſt a Cannon of 7 inches diameter haue to charge her with. And note, that for as much as now the ſhooting with Serpentine powder is not vſed, being of no great force, & the making of corne powder neuer better knowne, nor of more force than now it is made & daily vſed in ſhooting in great Ordinance; as alſo the great Ordinance now caſt, not ſo fully fortified with mettall as they ought to be, being made more nimble and lighter than in times paſt, therfore the experienced Gunners doe obſerue as a generall rule to abate $\frac{1}{4}$ part of the ordinarie charge of corne powder in all peeces aboue 6 inches bore.

How by knowing how much Serpentine powder will charge any peece of Ordinance, to know how much corne powder will do the like, or contrariwise by knowing how much corne powder will charge any peece of Ordinance, to know how much Serpentine powder will serue.

Question.

I demand how much corne powder will charge that Culuering that shoots 24 pound of Serpentine powder at a shoot?

Resolution.

You must note for a generall rule, that two parts of corne powder will doe as much as 3 parts of Serpentine powder: so that the proportion between the quantities or charges of these powders, is as 2 to 3, therefore I multiply 24 by 2, ariseth 48, which diuided by 3, my quotient is 16 pound: so much corne powder wil charge the said Culuering. Or if you know how much corne powder will charge her, you may know how much Serpentine powder will serue, in multiplying 16 pound the due charge of corne powder, by 3, and diuiding the product by 2, your quotient is 24, as before. In this order you may doe the like by any other peece. And note that her due charge of corne powder, will lesse hurt the peece, than of Serpentine powder, for if Serpentine powder be ramd any thing hard, it is long a fiering. And a little heate long continued (which the Serpentine powder will doe) dangereth the peece more than a great heate presently gone, which effect corne powder works.

How by knowing how far your peece will ſhoot with her due charge in powder and ſhot, how to giue a neare eſtimate how far ſhe will ſhoot with a charge more or leſſe than her common charge.

Queſtion.

Admit a Culuering ſhoote a bullet of 18 pound weight 900 paces, being charged with $\frac{2}{3}$ parts in powder of the bullets weight, I demand how far ſhould the ſaid peece ſhoot that bullet, if ſhee had beene charged with as much powder as the bullet weighed?

Reſolution.

By the rule of proportion I finde ſhe ſhould ſhoot $\frac{1}{3}$ part further than ſhee did at the firſt ſhot, being charged with $\frac{1}{3}$ part of more powder, that is 1200 paces: yet it is knowne ſhee will not driue the bullet full out the $\frac{1}{3}$ part of this range further, although ſhe will come very neare it, and the reaſon is, becauſe the bullet flieth in a circular proportion more or leſſe, a part of the range, after the inſenſible ſtreight line or motion of the bullet be paſt, according to the degrees of randon the peece is elenated at. Alſo the concaue of the peece being filled vp with the powder, wadd and bullet, further than it ought to be, is a hinderance to the range of the bullet in proportion, according to that little quantitie of the concaue which the overplus of powder and wad filleth vp; which though it be but little in compariſon of the whole concauity to the range, yet it is a great hinderance in the bullets range, for that the bullet being ſo much nearer to the mouth, is driuen into the ayre before the powder be all fiered, and haue effected his force thereon: ſo that giuing the peece her bullets weight in corne powder, ſhe

will ſhoote much further nor with an ordinarie charge, but it will both put the peece in danger of breaking, and thoſe that are neare therto in danger of their liues, if the peece be not all the better fortified with mettall.

How by knowing how much powder a few peeces of Ordinance haue ſpent, being but a few times diſcharged, to know how much powder a greater number of the ſame peeces will ſpend to be often diſcharged.

Queſtion.

If 4 Cannons being twice diſcharged at any ſeruice, ſhoote 240 pound of powder, how much powder will charge 5 Cannons to ſhoote euery one 6 ſhots?

Reſolution.

Worke by the double rule of proportion, ſaying; If 4 Cannons ſhoote 240 pound of powder, what will fine Cannons? your quotient will be 300 pound: then ſay againe, If 2 times diſcharging yeeld 300 pound of powder, what 6 times? and your quotient being 900 pound weight, ſheweth that ſo much powder is due to 5 Cannons, to ſhoote euery one 6 ſhots.

To know how much powder euery Cannon ſpent in the former concluſion at one ſhoote.

Queſtion.

If 5 Cannons burne 900 pound weight of powder, being but 6 times diſcharged, how much powder did euery one ſhoote at one ſhoote?

Reſolution.

Multiply 4 the number of peeces firſt propounded by 2, the times they were diſcharged, ariſeth 8, by which diuide

uide 240, the number of pounds in powder ſpent, the quotient is 30 pound, and ſo much powder did euery Cannon fire at one ſhoote. Or elſe you may multiply the other 5 Cannons by the times they were diſcharged, and diuiding that product by the powder ſpent, you ſhall haue 30 pound weight of powder in your quotient alſo.

How to know how much powder euery little caske or firken ought to containe, and how many of thoſe caskes makes a Laſt of powder, and how many ſhots any quantity of powder will make for any peece of Ordinance.

Euery little caske or firken being empty, ought to weigh 12 pound, and being filled ought to hold an hundreth pound weight of powder: ſo that the full caske ought to containe 100 of Haberdepoize weight, & 24 of thoſe caskes or firkens filled makes a Laſt of powder.

Queſtion.

How many ſhots will one of thoſe caskes filled with powder make to a Culuering that ſhootes 15 pound weight of corne powder at one ſhot?

Reſolution.

Diuide the 100 pounds of powder in each firken by 15, the quotient will ſhew you that 100 weight of powder will be 6 ſhots to a Culuering that burnes 15 pound of powder at a ſhoote, and 10 pound to ſpare.

How by knowing how many ſhots a firken of powder will make for a Culuering, to know how many ſhots a Laſt of powder will make for a Cannon.

Queſtion.

If a firken of powder of one hundreth weight charge a

Culuering

Culuering 5 times, ſhooting 20 pound of powder at euery ſhot, how many of thoſe ſhots will be in a Laſt of powder (containing 24 hundreth weight) to a Cannon that ſhoots 30 pound of powder at euery ſhot?

Reſolution.

Reduce 24 hundreth weight into pounds, you haue 2400 pound; then ſay by the rule of 3 direct; If 100 pound weight of powder be but 5 ſhot, what will 2400? and you ſhall haue in the quotient 120 ſhot, for the ſaid Culuering that ſhoots 20 pound weight at one ſhoote. And whereas the queſtion ſayes the Cannon ſhooteth 30 pound of powder at a ſhot, you muſt frame the backer rule of 3, and ſay, If 20 beare proportion to 120, what will 30? ſo multiplying 20 by 120, and diuiding by 30, the quotient is iuſt 80: ſo many ſhots of powder will be in a Laſt for any Cannon that ſhootes but 30 pound weight at a ſhot. The like is to be done with any other,

To know how many ſhots of powder will be in a Graund barrell for any peece of Artillery.

Queſtion.

If an ordinarie Culuering ſhoot 15 pound weight of good corne powder at one ſhoote, how many times will a Graund barrell full of powder ſerue to charge her, the ſaid barrell holding 300 weight?

Reſolution.

Diuide 300 by 15, the quotient is 20, your deſire: the proofe is eaſie; for multiplying 20 by 15, you haue 300 the number firſt propounded: the like is to be done if you would know how many ſhoots will be in a graund barrell, for any other peece of Ordinance, in diuiding the poundes of powder contained in the ſaid Barrell

by

by the number of pounds of powder due to charge the ſaid peece.

To know Arithmetically what proportion of euery receit is to be taken to make perfect good powder, what quantitie ſo euer you would make at a time.

Queſtion.

The beſt ordinary corne powder made in theſe daies, containeth 12 parts of Mr. 3 parts of cole, and 2 parts of Sulphur. The order how to compound and make the ſame is not peculiar to this Treatiſe, being meere Arithmeticall; I demand how many pound weight of euery ſort is to be taken to make 1000 pound weight of powder?

Reſolution.

Adde all the parts or pounds of the receits together, ariſeth 17 pound for your diuiſor. Then frame the golden rule, ſaying, If a mixture of 17 pound weight of powder, require 12 pound of the Salt-peter, what will 1000 pound weight? In multiplying and diuing according to the rule, the quotient will be 705 pound, and $\frac{15}{17}$ parts of a pound: ſo many pound of the Mr. is to be taken to make a thouſand pound weight. Againe, ſay by the ſame rule, If that a mixture of 17 pound weight, do require 2 pound of Sulphur, what wil 1000? your quotient will ſhew you, that 117 pound & $\frac{11}{17}$ is to be taken. And laſtly by the ſaid rule ſay, If a mixture of 17 pound take 3 pound of Cole, what will 1000 pound take? and your quotient will tell you that 176 pound and $\frac{8}{17}$ parts is to be taken. The which 3 quotient numbers being all added together, will be iuſt 1000 pound weight, and ſo proues the worke to be truely done.

And note that the goodnes or badnes of powder may be known diuers waies, as by the colour, the taſt of the tongue, the quicke burning, &c. Alſo the brimſtone is that materiall ſubſtance that is moſt apt to kindle with any ſparke, the cole moſt fit to continue or maintaine the flame, and the Mr. being reſolued into a windie exhalation worketh the effect, as chiefe and principall of the three.

Before I frame theſe concluſions following, of the randon or range of the bullet, and the diuerſitie thereof, it is requiſite to make knowne to the Reader, how that diuers haue written, and ſome will vaunt that by the range or flight of the bullet out of any one peece of Ordinance knowne, they will or can tell the vtmoſt range of all other, thinking that the range of the bullet out of any one peece, ſhould be proportional to the bullet and charge of powder out of any other peece. Alſo ſome do affirm, that out of any one peece of Ordinance diſcharged with ſundry quantities of powder, they can tell the vtmoſt range of the bullets diſcharged; and their reaſon is, that the range of thoſe bullets ſhall bee proportionall to the weight of powder wherwith they were charged. And hereupon ſome haue giuen out rules which are falſe & full of errors: for the diuerſity of proportions cannot by the plaine rule of proportion be reſolued, as they affirme: but this may they do; Out of any one peece of Ordinance charged with one and the ſame like charge in powder & bullet, find by the rule of proportion, the neare difference or ranges of the bullets, the peece being mounted or diſmounted at any degree of randon; or by knowing how many paces, yards, feet, or other meaſure any peece will reach at point blanke, by

knowing

knowing the point blanke and vtmoſt range of another peece of Ordinance, they may find the furtheſt range of the firſt. Or contrariwiſe, by knowing the vtmoſt range and point blanke of one peece, and the vtmoſt randon of another peece, they may find out the point blanke of that other peece, as by the rules following ſhall bee proued. And it is to be noted that any peece of Ordinance being mounted to the beſt of the randon or higheſt degree of the quadrant, the mouth and hollow cilinder of the ſaid peece, muſt be erected to 45 degrees, that is, at the 6 point of the skale in the quadrant (as the moſt part of quadrantes now are made :) but ſome peeces will ſhoote as far at the 5 point, or at 41, 42, or 43 degrees according as the winde is of calmeneſſe, for if any peece bee mounted higher than 45 degrees, ſhee ſhall ſhoote ſhorter in euery degree about the $\frac{1}{45}$ part of her vtmoſt range. And therefore to know how to worke theſe concluſions, you muſt buy an inſtrument Geometricall, or by ſome line of meaſure truely diuided, meaſure the diſtance from the peece to the place where the ſhot firſt fell or grazed, noting how many pearches, paces, yardes, or other meaſure that diſtance is; which knowne, diuide that diſtance by the degrees in the beſt of the randon, being 45, your quotient wil tell you how many paces, yardes, feete, or other meaſure your peece will ſhoote further or ſhorter in mounting or diſmounting a degree: the which knowne, as I haue ſaid, by one truly meaſured, you may before you ſhoote, know very neare how far or ſhort your peece will ſhoote, at the raiſing or diſmounting of any degree, allowing one & the ſelfe like proportions in charging, both with powder, bullet and wad.

How by Arithmeticke skill you may know how with one and the selfe same like charge in powder and shot, how much farre or short, any peece of Ordinance will shoote, in mounting or dismounting of any degree: whereby you may know how far your peece will shoote at any degree of the randon, by knowing the distance she shoots at the vtmost grade.

Question.

If a Cannon at her vtmost randon (that is, at 45 degrees) carry the bullet 1440 paces from the peece, how farre shall the same peece shoote being dismounted but one degree?

Resolution.

To answer this or all such like, I set downe the numbers according to the rule of proportion, and multiplying and diuiding accordingly, I finde she shall shoot short in dismounting a degree, 32 paces, or 53 yeards, or 160 foote, which substracted from 1440, rests 1408 paces; so farre shall the Cannon shoote in dismounting her one degree of her furtheſt range. Or you may doe the like in framing the golden rule, saying: If 45 degrees range 1440 paces, what will one? and you shall haue 32 paces in your quotient as before.

How by knowing the distance to the marke, by the conclusion or rule before, you may know whether your peece will shoot short, or ouer the marke, or you may know how far it is from your platforme to any marke, within the reach of your peece, onely by knowing the vtmost range of your peece, and the degrees shee is eleuated at.

Question

Queſtion.

Admit the ſame Cannon in the former concluſion, which ranged at the beſt of the randon 1440 paces, hauing the like charge in powder, ſhot and wad, is laid to ſhoote at a marke being mounted at 30 degrees, I demand how far it is from the peece to the ſaid marke, or how far the ſaid peece doth carry ſo mounted?

Reſolution.

To anſwer this, I multiply the paces my peece reacheth at the beſt of the randon, by thoſe degrees in the propoſition (to wit) 30 degrees, and there ariſeth 43200, which diuided by 45, my quotient is 960 paces, (that is, 40 paces leſſe than a mile) ſo farre will that peece ſhoot, being mounted at 30 degrees. And if you would know how much this is ſhort of the vtmoſt range, abate the ſame from the ſaid range, the remaine is your deſire. As 960 paces abated from 1440, reſts 480 paces, ſo much doth ſhee ſhoote ſhort of her beſt randon. In this order by 2 ſhoots knowne, you may know what any peece of Ordinance will doe being mounted aboue 10 degrees to the beſt of the randon, but vnder 10 degrees you ſhould erre ſomething in this practice, becauſe the range of the bullet flieth a great part of the way in an inſenſible ſtreight line, and the peece mouth eleuated aboue 10 degrees, ſhootes or driues the bullet in a more circular proportion.

The range or flight of the bullet by the draught in the next leafe may bee vnderſtood. And note that in ſeruice there is no peece of Ordinance lightlie mounted aboue 15 or 20 degrees, except morter peeces, and ſuch like.

How to make a table of randons, or go very neare to know the true range of the bullet out of all ſorts of peeces being mounted from degree to degree.

Many Authors haue taught how to make a table of randons, whereas ſome of them neuer ſhot in any peece of Ordinance in their liues. And for as much as I finde their writing and reaſons differing, I thinke it will bee a very hard matter to make a perfect table of randons, except the ſame bee tried and experimented with ſome peece of Ordinance in ſome conuenient ground. I neuer heard nor read of any that hath as yet fully put the ſame in practice, the which would be much auailable to euery Gunner, to know what euery peece would doe at the mount of euery degree or point in the quadrant, the motion or range of the bullet being ſomething variable at the mount of euery degree. You ſhall very neare find out the true range or randon of the bullet ſhot out of any peece of Ordinance, the peece mounted at any degree of randon, as thus:

Charge your peece with her due loading, in powder ſhot & wad, laying the peece at point blanke, which you may eaſily try, by putting the rule of the quadrant into the peece mouth, & coyning the peece at the breech, ſo as the plũmet may cut the quadrant in the line of leuel, as you ſee in the firſt figure hereafter drawn, that peece lieth point blanke: which done giue fire, & mark where the bullet firſt grazeth, after bring your peece to the ſame platforme, ſo as the wheeles and cariage ſtand neither higher nor lower than they did the firſt ſhoot: and being charged with one & the ſelflike quantity in powder, bullet & wad as before, the peece being of like temper raiſe her mouth one degree, as the ſecond figure

ſheweth: diſcharge her, and marke where the pellet falleth or grazeth firſt; then meaſure how far the firſt graze of the ſecond bullet is beyond the graze of the firſt bullet, ſo much will the peece conuey the bullet further at the mount of euery degree, or very neare therto. But being mounted aboue 20 degrees, ſhe will ſhoote ſhorter & ſhorter, a litle at the mount of euery degree to the beſt of the randon, according to the height & circular motion of the bullet. If the peece be mounted to the beſt of the randon, the plummet will cut the 45 degree of the quadrant, as the 3 figure ſheweth. Or you may make a table of randons like the other, as thus: Meaſure the diſtance the peece conueyeth the bullet at the beſt of the randon, from which abate the diſtance the peece conueyeth her bullet at point blank, diuide the remaine by 45, the quotient wil ſhew you how far the ſhoot is caried at the mount of euery degree: or diuiding the ſaid remaine by ſo many degrees as you would eleuate your peece at, the quotient will likewiſe ſhew you how far the bullet doth range beyond point blank. *Example.*

If a Cannon at point blanke range 300 paces, and at the beſt of the randon ſhoote 1500 paces, how far ſhall ſhe ſhoote at the mount of one degree?

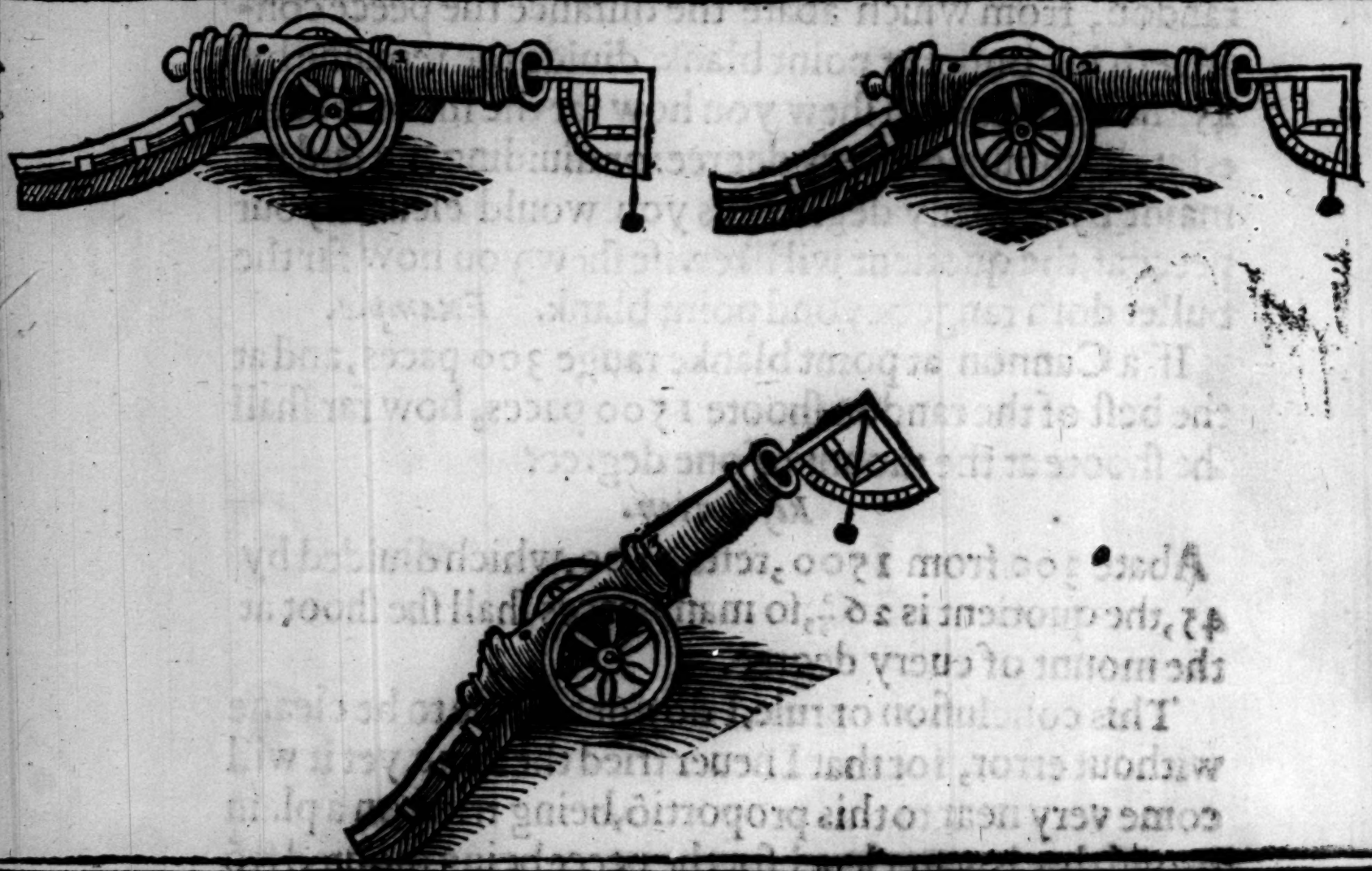
Reſolution.

Abate 300 from 1500, reſts 1200, which diuided by 45, the quotient is $26\frac{2}{3}$, ſo many paces ſhall ſhe ſhoot at the mount of euery degree.

This concluſion or rule, I do not affirme to be cleane without error, for that I neuer tried the ſame, yet it will come very near to this proportiõ, being tried on a plain groũd that is water leuel, for the peece being moũted frõ 1. to 10 degrees, conueyeth the bullet with litle bending

at

at the fall therof, and from 10 degrees to 20, as the motion of the bullet decreaseth: so it falleth more bowing than in the first 10 degrees. And mounted from 20 grades, to the best of the randon, conueyeth the bullet in a more circular course. And it is to be noted, that any peece of Ordinance hauing her due charge, will driue the bullet more ground mounted at 20 degrees, than from 20 grades to the best of the randon. And being truely loaden and discharged at the best of the randon, will driue the bullet 5 times the distance of her leuell range, or rather better.



How you may Arithmetically know how much wide, ouer, or ſhort, any peece of Ordinance will ſhoote from the marke, by knowing the diſtance to the marke, and how your peece is laid to ſhoote at the ſaid marke.

Queſtion.

If a Culuering or Cannon of 10 foote long, be ſhot at a marke 700 yardes from the peece, the mouth of the ſaid peece planted an inch wide, how far ſhall the bullet light wide of the marke?

Reſolution.

Reduce the meaſure of the length of the peece into inches, becauſe the denomination of wideneſſe is by inches, and the peece of 10 foote length, will yeeld 120 inches. Likewiſe reduce the length from the peece to the marke into inches, you haue 25200 inches. Then by the rule of proportion, ſay, if 120 inches ſhoot wide one inch, what will 25200 inches? And in multiplying and diuiding according to the rule, you ſhall finde in your quotient 210 inches, that is, 17 foote $\frac{1}{2}$: ſo much ſhall the bullet light wide of the marke. For this is a generall rule, that looke how many times the length of the cilinder or concaue of the peece is to the marke, ſo many inches ſhall the peece ſhoote amiſſe, being laid ouer one inch, or vnder, or wide of the marke, if the winde doe not alter it. The like is to be done of any other.

A remedy to lay your peece ſtraight, if ſhe lie either ouer, vnder, or wide of the marke.

Let a plumbe line fall perpendicularly ouer the middle part of the breech of the peece, and with a hand-ſpike

or leuer, winde the carriage of the peece to and fro till you eſpie the middle part of the mettall at the mouth of the peece, and the ſaid line diuide the marke in 2 equall parts: ſo ſhall you make a ſtreight ſhot, giuing the peece her true diſparture and length.

Another way.

Or you may take the true diameter of the concaue at the mouth of the peece, laying an inch rule to the ſame, diuide the ſaid diameter in 2 equall parts; to the point of which diuiſion being the center of the cilinder of the peece, let a threed and plummet fall, or elſe erect a ſquire, ſo as the containing angle touch the center or middle point of the diameter, by the edge of which rule or ſquire draw a line with the point of your knife, from the height of the mettall at the mouth: that line would croſſe in the center if it were continued, and it is a perpendicular or plumbe line to the other; by which line or ſtrike ſo drawne, with a little peece of ſoft waxe, ſet vp a ſtraight ſtraw, to reach a little aboue the mettall. And knowing likewiſe the middle mettall at the breech of the peece, it is an eaſie matter to make a ſtraight ſhot, if the 2 ſights (to wit) the ſight at the breech and mouth bee laid ſo as they diuide the ſaid marke in 2 parts: for this is generall, that any three things that the eye can comprehend at once, being equall with the eye, are in a ſtraight line from the eye, whether the ſame bee at aſcent or deſcent.

The line or ſtrike thus drawne at the mouth of the peece, will ſhew you preſently where and how to ſet vp your diſparture of your peece at any occaſion.

In ſhooting without diſparting your peece at any marke within point blanke, to know how farre the bullet will flie ouer the marke by knowing the diſtance to the marke.

Queſtion.

A Cannon or Culuering of 12 foote in length, hauing three inches more mettall at the breech on each ſide than at the mouth, ſhooting at a marke ſuppoſed to bee within the leuell range, and 600 yards from the mouth of the peece, being ſhot without her diſparture, how much ſhall the ſhot flie ouer the marke?

Reſolution.

It is a generall rule, that looke how much the peece is thicker of mettall, in any one ſide at the breech, than at the thickeſt part at the mouth, as alſo looke how many times the length of the peece is to the marke, ſo many times that ouerplus of thickneſſe ſhall the bullet flie ouer the marke, being no higher than the peece, and the ſaid peece diſcharged without her diſparture.

Example.

Diuide 600 yardes (being the diſtance from the peece to the marke) by 4, (the length of the peece) your quotient is 150, which multiplyed by 3 inches the ouerplus of mettall, ariſeth 450 inches: ſo much ſhall the bullet flie ouer that marke, the marke being placed on the ſide of a hill or bearing banke, and within the leuell range of the peece.

In like manner ſhooting at any marke within

½ the vtmoſt range of the peece, and not diſparting your peece, you ſhall ouer-ſhoot ſomething, giuing the peece her due length and due loading.

How you may lay your peece point blanke without inſtrument.

If you bring the height of the mettall at the mouth of the peece, and the height of the mettall at the breech, equall with the horiſon, the hollow cilinder of the peece will lie point blanke.

How you may Arithmetically diſpart any peece of Ordinance truely diuers waies.

If you meaſure with a paire of Callapers the greateſt height of mettall at the mouth of the peece, and likewiſe at the breech, abating the leſſe out of the greater, ½ the remainder is the iuſt diſparture.

Example.

A Culuering that is 19 inches high at the greateſt part of mettall in the breech, will bee 13 inches high at the greateſt part of mettall at the mouth: which 13 inches abated from 19, reſts 6, which diuided in 2 equall parts, the quotient being 3 inches ſheweth the true diſparture of that Culuering.

Another way to diſpart any peece without Callapers.

Take a line and meaſure the greateſt circumference of mettall in the breech, then multiply that meaſure by 7, diuiding the product by 22, the quotient is the diameter, or height of the circumference. Likewiſe meaſure the greateſt circumference of mettall at the mouth, multiplying that meaſure by 7, diuide by 22 as before, the quotient will ſhew the diameter of the mettall at the mouth,

mouth: ſubſtract that diameter laſt found, from the diameter at the breech ½ the remaine is the true diſparture.

Example.

A Culuering whoſe greateſt circumference of mettall at the breech containeth 66 inches, and at the mouth 44 inches, I demand how high is the diameter of the mettall both at the breech and mouth, as alſo what is the true diſparture of that peece?

Reſolution.

Multiply 66 by 7, ariſeth 462, diuide by 22, the quotient is 21, the height of the mettall at the breech: likewiſe multiply 44 by 7, you haue 308, diuide by 22, the quotient is 14, the height of the mettall at the mouth, which 14 abated from 21 reſts 7, the which 7 diuided in 2 equall parts, yeelds 3 inches ½ for a part, the true diſparture of that Culuering.

This is one of the principalleſt points belonging to a Gunner, to know truely how to bring the concaue of the mettall of his peece euen. Diuers other waies there be to doe the ſame: As for chambred peeces, there is no perfect or generall rule, but is to bee conſidered according to the chamber or concaue of the peece. Euery reaſonable Gunner may iudge in that caſe.

How by Arithmeticall skill you may mount any great peece of Ordinance, by an inch rule vnto 10 degrees of the quadrant, if you want a quadrant or other inſtrument.

Firſt you muſt meaſure the iuſt length of the Cannon or bore of the peece: reduce that meaſure into inches, and double the ſame: afterwards multiply the number of inches ſo doubled by 22, and diuide by 7, and note what

the quotient number is, which quotient diuided by 360 the degrees contained in the whole circumference of euery circle, the laſt quotient number will ſhew you the number of inches, and parts of an inch, that will make a degree in the quadrant for that peece.

Example.

Admit there is a Saker or Fawcon, whoſe concaue or bore containeth iuſt 7 foote in length, and that you deſire to know what parts of an inch rule will mount her to one degree of the quadrant, you muſt reduce 7 foote into inches, and you haue 84 inches, that 84 doubled is 168, the which multiplied by 22 ariſeth 3696, the which diuided by 7, the quotient will bee 5283; that quotient number being diuided againe by 360, wil yeeld $1\frac{7}{15}$ (that is) one inch and $\frac{1}{2}$, wanting $\frac{1}{15}$ part of an inch. So I affirme that any peece of Ordinance whoſe chaſe or bore is but 7 foote long, being mounted by an inch rule one inch and $\frac{7}{15}$ parts, that peece ſhall lie iuſt the height ſhe would haue done if you would haue mounted her one degree of the quadrant. The like order is to bee obſerued in mounting any other peece of Ordinance by an inch rule, of what length ſoeuer. And note that in mounting any other peece of Ordinance, to any degree of the quadrant, by a Geometricall quadrant, you muſt put the rule of the quadrant into the peece mouth, lifting the peece vp or downe with a leauer or hand-ſpike towards the breech, till the plummet cut iuſt vpon that degree of the quadrant you deſire.

But to mount her by an inch, you muſt place the rule vpon the higheſt part of the mettall at the breech of the peece, coyning the peece vp or downe, till through the ſight or ſlit in your rule (be lifted to that part or diuiſion

in

in your rule that anſwereth the degrees you deſire) you eſpie the Carnoize or higheſt part of the mettall at the mouth of the peece, and the marke, all 3 in a ſtraight line.

If you would mount the ſame peece to 2 degrees of the quadrant by an inch rule, you muſt multiply the meaſure in your rule laſt found, being 1 inch $\frac{7}{15}$ parts by 2, in the order of fractions, and you ſhall haue $\frac{44}{15}$, the which 44 being the numerator of the fraction diuided by 15 the denominator, the quotient being 2 inches $\frac{14}{15}$ is your deſire: ſo may you affirme that 3 inches by the rule wanting $\frac{1}{15}$ part of an inch, will make 2 degrees by the quadrant.

And note, that looke how much you would haue your peece mounted by an inch rule for to anſwer any number of degrees vnder 10, either multiply that number by the number of inches and parts of an inch, that makes a degree of the quadrant, or elſe working as you did the firſt concluſion, multiplying the firſt product by the number of inches deſired, and diuiding that product by the numbers afore mentioned, your laſt quotient will reſolue you of your deſire.

Example.

I demand how much the peece afore mentioned ſhould be eleuated by an inch rule, to anſwer to 8 degrees of the quadrant?

Reſolution.

Reduce the length of the bore of the peece into inches, as afore is ſhewed, doubling that meaſure, and it makes 168, as you ſee in the 1 concluſiō: which 168 inches multiplied by 22, yeeldeth 3696 inches, the which product afterwards multiplied by 8, ariſeth 29568, which ſumme diuided by 7, the quotient is 4224: the ſame diuided

by

by 360, yeelds in the quotient 11 inches $\frac{11}{15}$ parts of an inch, ſo many inches and parts of an inch muſt the ſame peece be eleuated to with an inch rule, to anſwer to 8 degrees of the quadrant, as by triall you may finde.

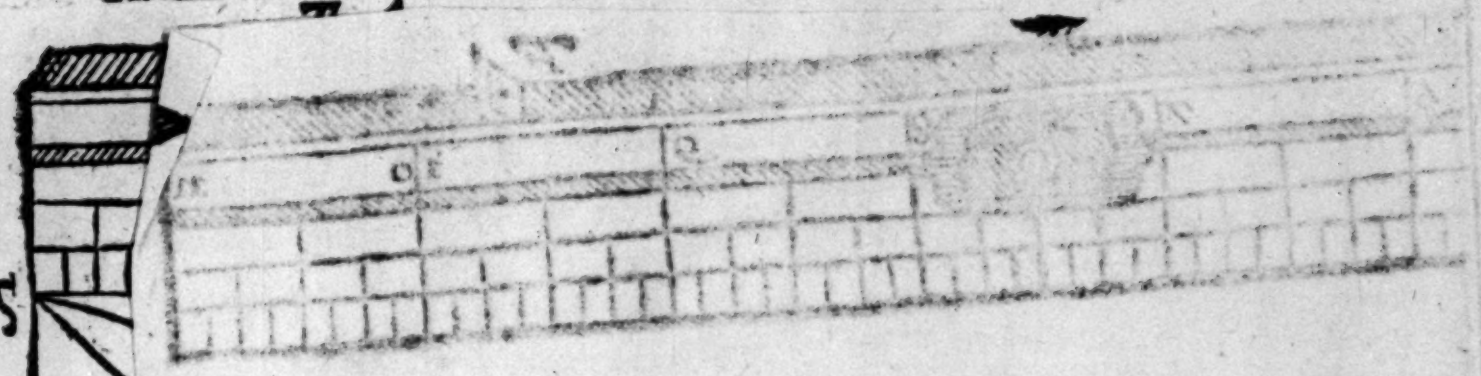
How by Arithmeticke skill you may know the true thickneſſe of mettall in any part of any peece of Ordinance.

Take a paire of callapers, and meaſure the height of the out-ſide of the mettall in that place of the peece whereas you deſire to know the thickneſſe of the mettall, then with an inch rule, or elſe a paire of ſtreight compaſſes, meaſure the diameter of the bore, or concaue of the peece, abating the height of the ſaid diameter from the height of the whole thicknes of that part of the peece ſo meaſured. And note the remainder, the which diuide in 2 equall parts, and the one of thoſe parts is the iuſt meaſure of the thickneſſe of the mettall in that part of the peece.

Example.

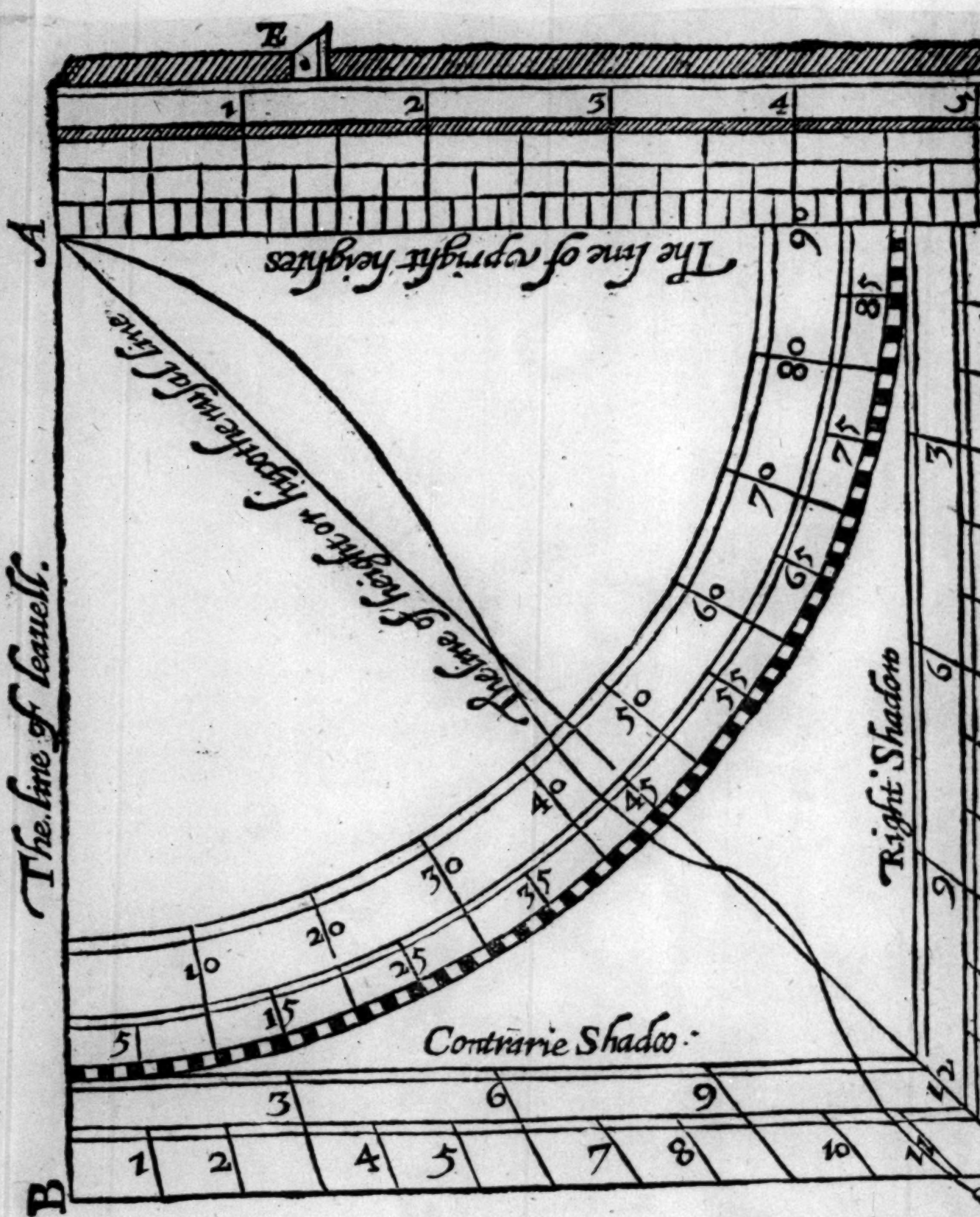
I prooued this concluſion with a Culuering, whoſe bore or concauity at the mouth was 5 inches $\frac{1}{2}$ height, & I found that the thicknes or height of the whole circumference of the ſaid peece at the touch-hole, was 16 inches $\frac{1}{3}$, from the wich I abated 5 inches $\frac{1}{2}$ (fraction wiſe) reſts 10 inches $\frac{5}{6}$ parts of an inch; that diuided in 2 equal parts, the quotient is 5 inches, and $\frac{5}{12}$ or 5 inches $\frac{1}{2}$ wanting the $\frac{1}{12}$ part of halfe an inch, ſo thicke was the mettall of that Culuering at the touch-hole.

Likewiſe I ſearched for the thickneſſe of mettall in the ſame peece at the end of the trunions, and I found that the thicknes or height of the ſuperficies of all the mettall there



The Line of Leuells.

pt the [illegible], being 8 inches, and the remaine was 8 inches, which diuided in 2 equall parts, my quotient being 4 inches, shewed the true thickneſſe of mettall



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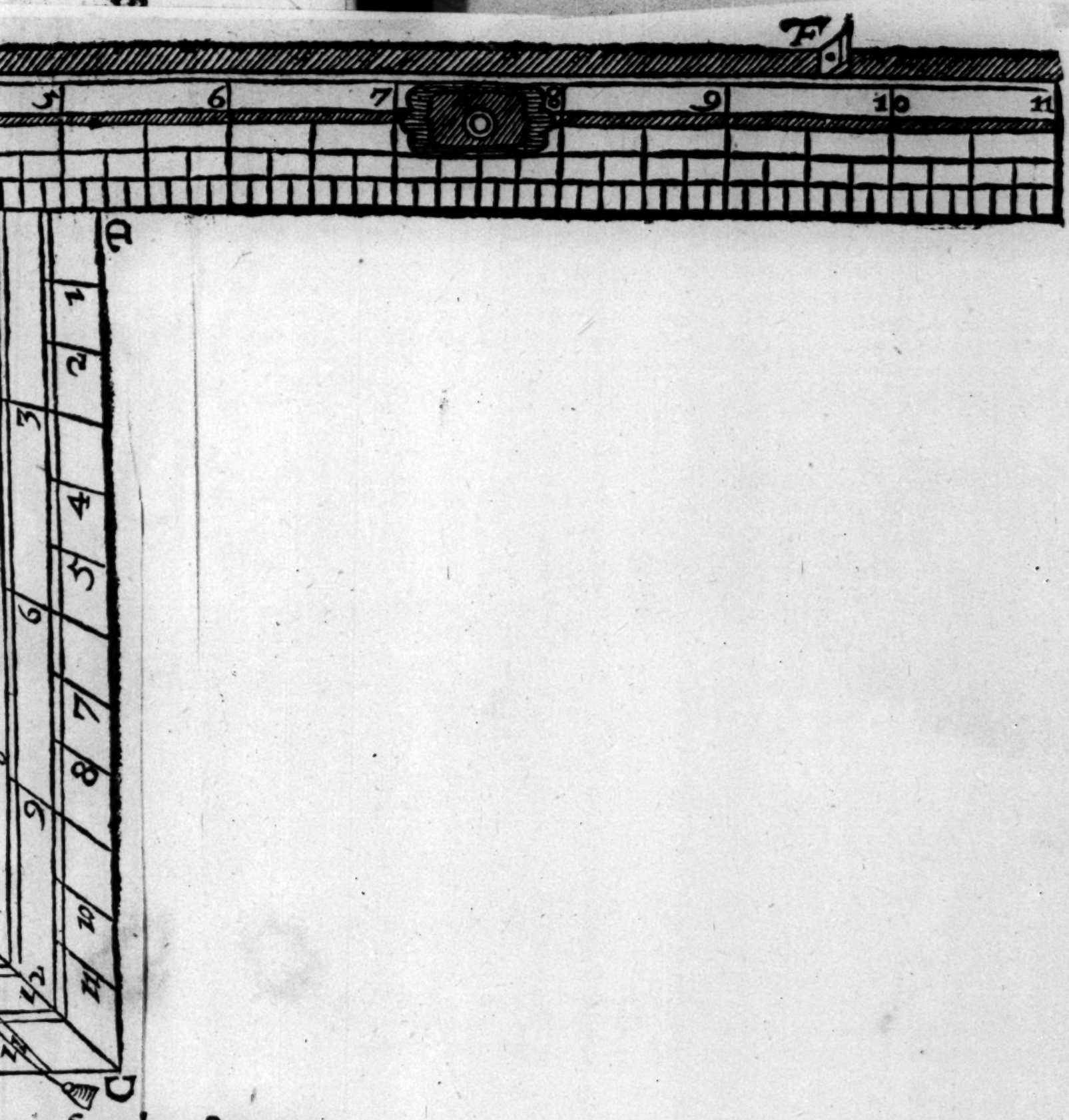
of the peece, being 8 inches, and the remaine was 8 inches, which diuided in 2 equall parts, my quotient being 4 inches, shewed the true thicknesse of metta



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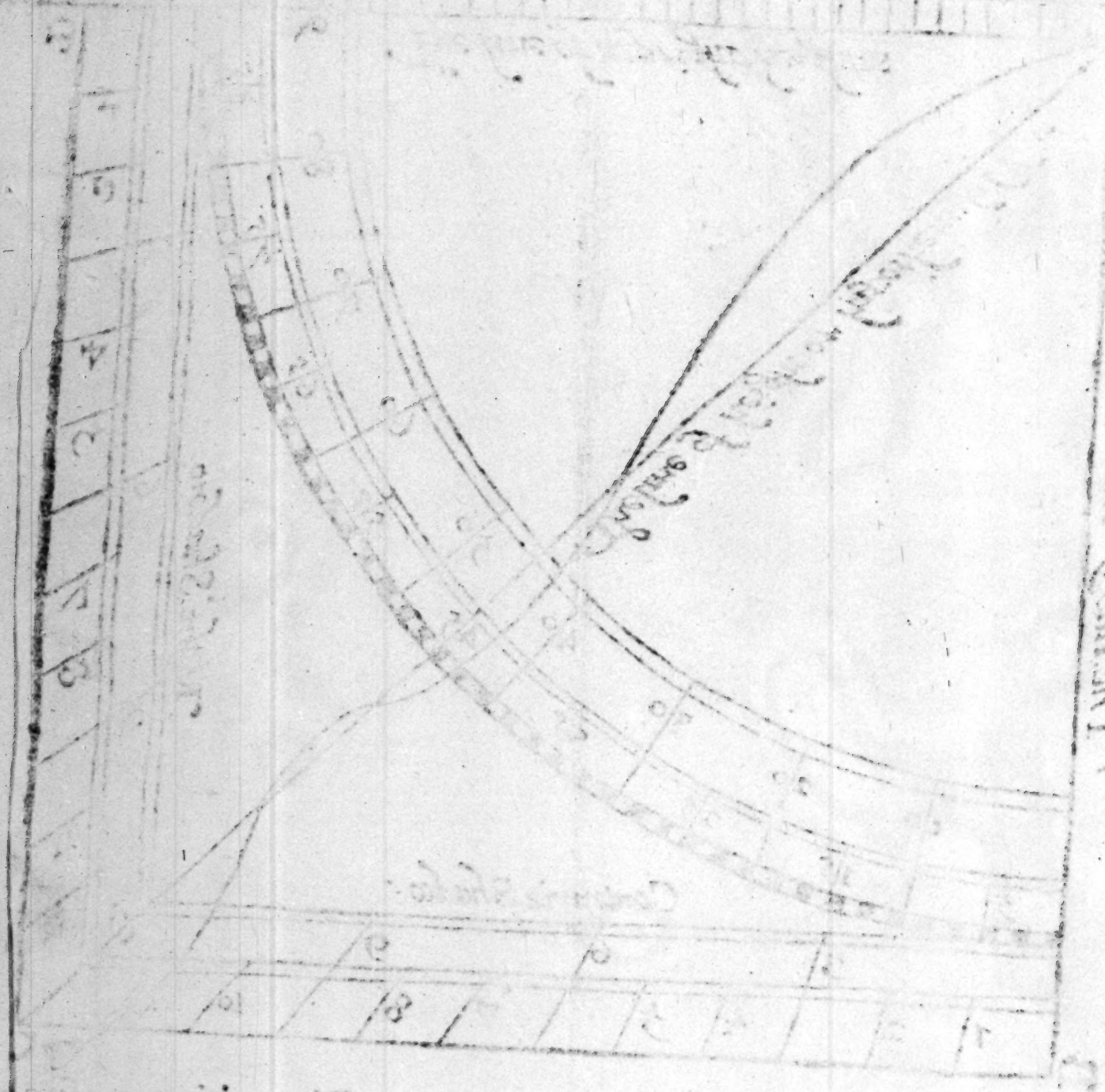


same peece at the end of the trunions, and I found that the thicknes or height of the superficies of all the mettall there

there contained 13 inches, from which I abated the diameter or concaue at the mouth, being 5 ½ inches, reſted 7 ½, which diuided in 2 equall parts, the quotient being 3 inches ¼ ſhewed the true thicknes of the mettall at the trunions. In this order you may finde the true thickneſſe of mettall in any part of any peece of Ordinance.

Another way to know the thickneſſe of mettall in any part of any peece of Artillerie.

Take a letherne girdle, and gird about that part of the peece you deſire the thickneſſe of mettall, lay the ſame meaſure to an inch rule, and note how many inches or other meaſure the ſame containeth: then multiply that meaſure by 7, and diuiding the product by 22, your quotient is the true meaſure of the wholé thickneſſe of the peece in that place. Then ſubſtracting the diameter of the bore or concauity of the peece from that quotient, note the remainder. Diuide that remaine in two equall parts, the one of thoſe parts is the thickneſſe of the mettall in that part of the peece ſo meaſured.

Example.

I prooued this concluſion with a demy Cannon of ſixe inches diameter, in girding the ſame about with a line hard behind the trunions, and laying the ſame to an inch rule, it contained 44 inches, which ſumme multiplied by 7, amounted to 308 inches: that ſum diuided by 22, my quotient was iuſt 14. And ſo many inches was the height of the whole mettall in that part of the peece, out of which quotient I did abate the diameter or bore of the peece, being 6 inches, and the remaine was 8 inches, which diuided in 2 equall parts, my quotient being 4 inches, ſhewed the true thickneſſe of mettall

in that part of the peece, being hard behind the trunions towards the breech.

And it is to be noted, that euery peece of Ordinance if it be truly fortified with mettall, ought to containe as much mettall in thickneſſe round about, ſo farre as the chamber where the powder and wad lyeth, as the bullet is in height.

How to make a good ſhot in a peece that is not truly bored: or to know how much any peece will ſhoote amiſſe, that is thicker of mettall on the one ſide than on the other, if you know the diſtance to the marke.

Queſtion.

A certaine Gunner hauing ſhot diuers times in a Cannon at a marke ſuppoſed to be 500 paces from the peece, findeth ſhee ſhooteth ſtill towards the right hand, and ſearching whether the fault were in himſelfe, or ſome impediment in the peece, he findeth that the peece is 2 inches thicker of mettall on the right ſide than on the left. And therfore requeſteth how to lay the concaue of the peece (being 9 foote in length) equall with the marke, ſo as he may make a ſtraight ſhot.

Reſolution.

To doe this or the like, there is a generall rule, that looke how oftentimes the length of the cilinder or concaue of the peece is to the marke, which is eaſily done by diuiding the diſtance to the marke, by the length of the concaue of the ſaid peece. And knowing likewiſe how much the one ſide of the peece is thicker than the other, the one halfe of that ouerplus being multiplied by the quotient firſt found, the product will ſhew you how much

much the peece ſhooteth wide of the marke. And this is a generall rule : that looke which ſide of the peece is thickeſt of mettall, towards that ſide ſhall the bullet fall, for that the thinner ſide is more ſmart, and the thicke ſide more dull in heating.

Example.

The Cannon in this concluſion, is ſaid to be 2 inches thicker of mettall more in thickneſſe on the right ſide than on the left. And the diſtance to the marke is ſuppoſed to be 500 paces, (that is, 2500 feete,) the which diuided by 9 feete, being the length of the hollow cilinder of the Cannon, yeeldeth in the quotient 277 feete $\frac{7}{9}$, the which multiplied by $\frac{1}{2}$ the ſuperfluitie of the mettall being one inch, makes 272 feete $\frac{7}{9}$ ſtill, and ſo much wide of the marke ſhould the ſaid peece haue ſhot at ſuch a diſtance, although ſhee had beene laid full againſt the mids thereof.

How to remedie your peece being thicker of mettall in one part than another to make her ſhoote ſtreight.

You muſt firſt ſearch your peece with an inſtrument, to know which is the thicker ſide, then diuide the ouerplus of mettall in 2 parts, ſetting the diſparture of your peece one of thoſe parts towards the thickeſt ſide of the peece mouth, and bringing the midle part of mettall at the taile of your peece, that diſparture and the midle of the marke, all in one ſtreight line, giue fire and you ſhall make a ſtreight ſhot. But beware of ouercharging of ſuch peeces, for they are dangerous.

If the thickeſt part of the mettall bee aboue, then you ought to make your diſparture one inch more: if vnder (I meane towards the carriage) an inch leſſe.

To know the different force of any two like peeces of Ordinance planted against an obiect, the one being further off from the said obiect than the other.

Question.

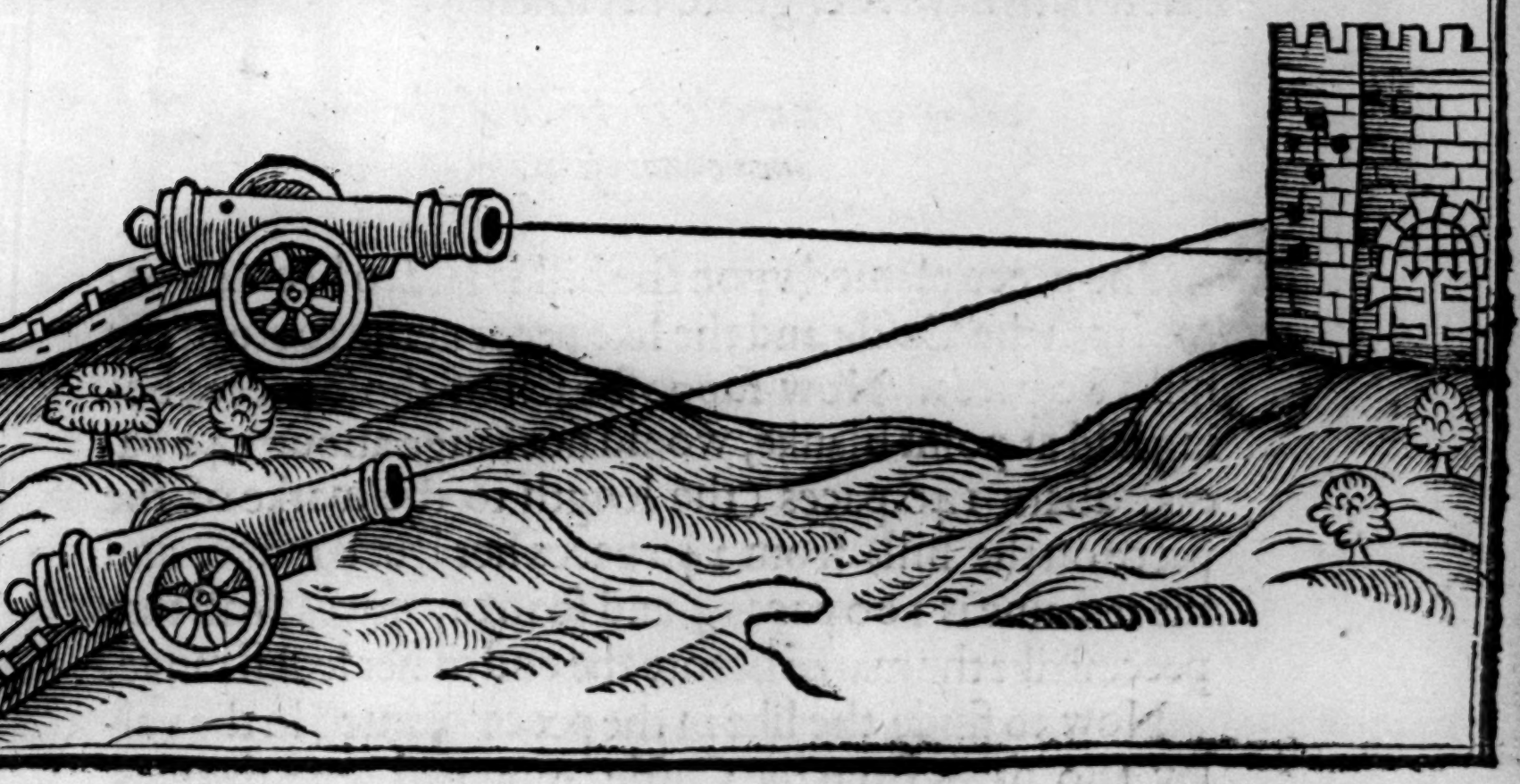
Admit there is a Castle or Fort to be battered, being situate vpon a hill, which hill is 50 paces in height, and that 140 paces from the said Castle, there is another hill, of equall height to that hill whereon the Castle is built, and Ordinance planted thereon to beat or batter the Castle wall, and in the valley at the foote of the said hill 180 paces off from the Castle hill, there is Ordinance planted, and mounted at 20 degrees, to shoote and beat down the said Castle: I would know whether the Ordinance in the valley being 180 paces distance from the Castle, and mounted at 20 degrees, or the Ordinance on the height of the hill, lying leuell to shoote a little aboue the base of the wall, being distant there from 140 paces, shall worke the greatest effect in battering downe the said Castle wall, the said peeces being of like length and height, and hauing like charge in powder and bullet?

Resolution.

To resolue this or the like, a man would thinke that the peece planted on the height of the hill, lying leuell to shoote a little aboue the ground-worke of the Castle, would batter soreſt, because she is neareſt: yet by experience we finde the contrary, for the Castle being a great way within the reach of both the peeces, that peece shall not onely shoote much further that is any thing eleuated, but also pierce much sorer, by so much as she is able to ouer shoot the other selfe like peece that lyeth leuell: albeit

albeit the ſaid peece ſo eleuated, bee planted furtheſt off from the ſaid reſiſting obiect: for euery Gunner knoweth, and reaſon and experience doth teach euery reaſonable man, that no peece of Artillery will ſhoot ſo far at point blanke, as when the ſame is eleuated at any number of degrees; becauſe the bullet being ponderous, flieth more heauily and ſooner declineth, being ſhot out of any peece lying leuell, than out of any ſuch like peece mounted at any degree of the randon. So that of force it muſt needs follow, that the peece planted in the valley 180 paces off from the Caſtle, ſhall pierce and batter a great deale ſorer than the like peece planted on the height of the hill being but 140 paces from it.

Example.



Example.

Suppoſe a Cannon or Culuering at point blanke ſhoot 240 paces, and being mounted at one degree out-ſhoote the ſame 30 paces, what will the ſaid peece doe being mounted 20 degrees?

By proportion I find, that if at the mount of one degree, any bullet range 30 paces beyond the leuell range, that at 20 degrees it ſhall out-flie the ſame 600 paces: albeit the ſaid bullet range not in euery degree a iuſt like number of paces, yet the proportion will be very neare thereto. And becauſe the peece at the foote of the hill is ſaid to bee 40 paces further from the Caſtle, than the like peece planted on the height of the hill, I abate 40 out of 600, reſts 560 paces: ſo farre would the peece in the valley out-ſhoote the other like peece on the hill; ſo that it muſt needs follow, her bullet ſhall pierce foreſt, for that it hath moſt ſtrength to flie furtheſt.

Another example or triall of the former concluſion.

The peece planted vpon the hill, is ſaid to bee 140 paces from the Caſtle, and the like peece at the foote of the hill 180 paces. Now ſuppoſe each of thoſe peeces being laid at point blanke, would not range aboue 240 paces, abate 140 paces (the length to the marke of the peece on the hill) from 240 paces her leuell range, and the remaine is 100 paces; and ſo many paces ſhall that peece ſtrike the marke before the end of her leuell range.

Now to finde the like in the peece planted in the valley 180 paces from the Caſtle, mounted at 20 degrees,

I finde by the concluſion afore ſet downe, that ſhee ſhall out-ſhoote the other 600 paces: ſo that abating the diſtance from the peece to the Caſtle, being 180 paces from 840 paces, her whole range mounted at thoſe degrees, there remaines 660 paces. And foraſmuch as the ſaid peece eleuated at 20 grades, doth ſtrike the marke 660 paces before the full end of the range of her bullet, it muſt of force pierce or batter ſorer than the other peece whoſe bullet beates the marke but 140 paces before the full end of his range.

How you may hauing diuers kindes of Ordinance to batter the wals of any Towne or Caſtle, &c. tell preſently how much powder will loade all thoſe Ordinance one or many times.

Queſtion.

There is a Caſtle beſieged, and to batter the ſame there is appointed 4 Cannons, 6 demy Cannons, 6 Culuerings, 8 demy Culuerings, and 5 Sakers: theſe peeces are charged euery time with corne powder, the whole Cannons ſhoote at euery ſhot 32 pound of powder a pecce, the demy Cannons 18 pound, the whole Culuering 16 pound, the demy Culuering 12 pound, and the Sakers 6 pound a peece. All which peeces being 10 times diſcharged, did make a breach ſufficient for 9 or 10 men to enter in by ranke (a breach of ſuch a widenes is thought ſufficient to bee aſſaultable,) I demand how much powder was ſpent before the breach was made?

Reſolution.

Reſolution.

To anſwer this demand, I multiply the number of euery ſort of peeces, by the weight in powder that one of them ſhootes, and the product ſheweth me how much powder euery ſort of the ſaid peeces did ſpend at one bout: then I adde euery number together, and the totall of that addition ſheweth mee how much powder will loade all thoſe peeces one time, which addition multiplied by 10, being the times they were ſuppoſed to bee diſcharged, the product ſheweth the iuſt quantitie of corne powder occupied at the ſaid ſiege by the great Ordinance.

Example.

I multiply 32 pound the weight of powder due to loade euery Cannon by 4 the number of Cannons, ariſeth 128. Likewiſe 18 pound of powder being the duty of euery demy Cannon multiplied by 6 the number of the ſame peeces, ariſeth 108, and 16 pound of corne powder being the ducty of euery Culuering multiplied by 6 the number of thoſe peeces, is 96. And 12 pound of powder being the due loading of euery demy Culuering multiplied by 8. the number of the ſame is 96. And laſtly, 6 pound of powder the duety of euery Saker, multiplied by 5 the number of that ſort of peeces, is 30. Theſe ſummes or additions put together makes 458 pound weight of powder: and ſo much will diſcharge all thoſe peeces one time; the which ſumme multiplied by 10, is 4580 pound of powder, that is, two Laſt of powder wanting 220 pound. In this order if you haue 20 Laſt of powder, by knowing the number of euery ſort of ſeuerall Ordinance, you may preſently know

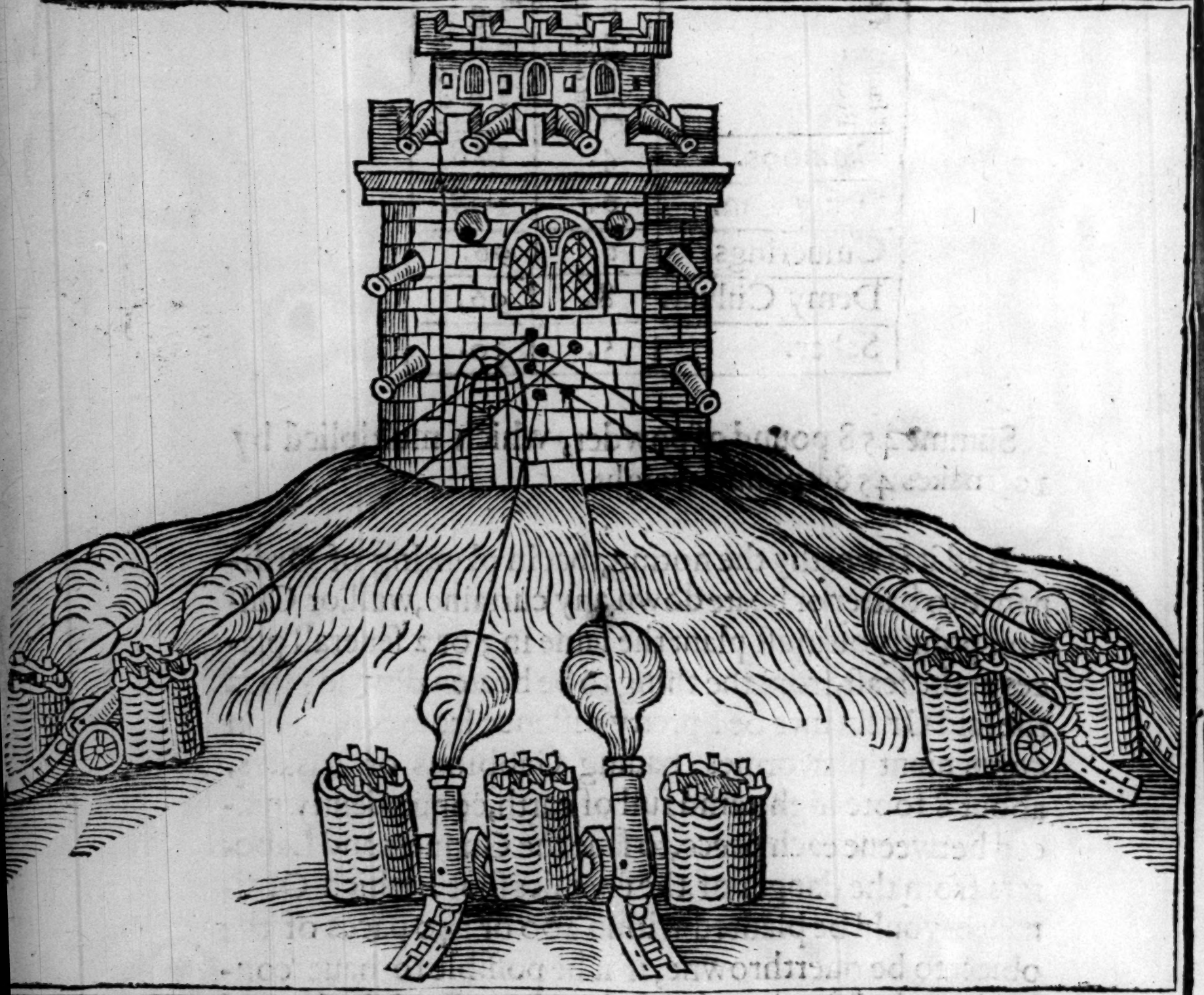
know how many ſhots, or how many times the ſaid powder will loade all the ſaid Ordinance, as this Table ſheweth.

Names of the Peeces.	Number of each ſort of Peeces.	Powder due to loade each ſort of Peeces one time.
Cannons.	4.	128.
Demy Can.	6.	108.
Culuerings.	6.	96.
Demy Culuer.	8.	96.
Saker.	5.	30.

Summe 458 pound of powder, which multiplied by 10, makes 4580 pound weight.

And it is worthy the noting, that in planting of Ordinance to batter or beate down any curtaine, wall, or Cullion point, you muſt plant the ſame in 3 or 2 ſeuerall places at the leaſt, from the thing to be beaten downe; ſo as the ſaid Ordinance be a pretty diſtance from other, vpon conuenient platformes, hauing Gabbions or Baskets, about 8 foote high, ramd full of earth, conueniently placed betweene each peece, to ſaue the Gunners and Laborers from the danger of the enemies ſhot: which Ordinance would be planted within 200 or 240 paces of the obiect to be ouerthrowne, if it be poſſible to haue conuenient platformes and to bring them ſo nigh the ſaid obiect. The which Ordinance, if ſo you haue made 3

mounts or platformes, the Ordinance from the 2 ſide mounts doth coine or cut out that which the Ordinance from the middle mount doth batter or pierce, or ſhake, as this draught here drawne ſheweth.



The

The beſt ſhooting to batter downe the broad ſide or curtaine of any wall, is to leuell ſomething vnder the middle part of the wall, and after to ſhoot 2 or 3 foote higher: for the lower part being beaten downe, the height or vpper part of the ſaid wall muſt fall of neceſſitie. And a ſpeciall regard muſt be had to giue fire from each platforme or mount at one inſtant, for that the bullets beating all together, doe more ſhake and batter the ſaid wall, than lighting now one and then another.

In the figure or draught which I haue drawne ſhewing how Ordinance may be planted to ding downe or batter the broad ſide or curtaine of any wall, Caſtle or Fort, the middle Ordinance placed on the middle mount or platforme, directly againſt the obiect to bee beaten downe, are called the peircers, and are onely to ſhake and beate the wall, and the Ordinance on the two other ſide mounts, or platformes ſhooting ſomething ſlanting, are to coyne or cut out that which the Ordinance from the middle platforme doth ſhake or looſe. The Baskets ramd full of earth, being placed betweene each peece of Ordinance are to defend the Gunners and Labourers from hurt of them that are beſieged, as afore I haue ſaid.

And furrher it is to bee noted, that to batter the coyne or cullion point of any wall, two places is ſufficient to plant your Ordinance in. Alſo you may batter and beate downe the wall of a Towne or Caſtle as well by night as day, ſo as the enemie ſhall haue no time to build vp in the night that which was dung downe in the day, as thus: Lay your peece or peeces, to the marke in the day light, and note well what degree of the quadrant ſhee lieth at, which is

ſoone done in putting the rule of your quadrant into the peece mouth, ſo laid againſt the marke, letting a line and plummet fall to the ground from the ſaid point of your quadrant, and at the lighting of the plummet on the ground, there driue in a ſtake or wooden pin; and letting a plumbe line fall likewiſe from the middle part of the taile or breech of your peece to the ground, driue therein another ſtake into the ground, then ſtretch a line from the ſaid 2 pinnes, ſo as the ends of the ſaid line may reach 2 or 3 yards further than the pinnes at each end. And there make them faſt in driuing a pin of Wood or Iron into the ground at each end, then bringing your peece or peeces to lie ſtraight aboue the ſaid line or lines ſo drawne (which is eaſily done hauing a lanterne with a cloſe couer) you may both charge and recharge, and ſhoote as well by night as day, according to your deſire.

How you may know the true weight of any number of ſhot, for ſeuerall peeces of Ordinance, how many ſoeuer they be, and how many Tun weight they doe all weigh.

Queſtion.

Suppoſe a Ship is loaden with [redacted]llets to be carried to the ſiege of a Towne, &c. in which ſhip is 500 ſhot for whole Cannons, 800 demy Cannon ſhot, 900 Culuering ſhot, 1000 demy Culuering ſhot, 1100 Saker ſhot, 1200 Minion ſhot, and 1400 Fawcon ſhot, the queſtion is to know the true weight of all the ſhot, and how many Tun they doe all weigh.

Reſolution.

Reſolution.

In the beginning of this Treatiſe, I ſhewed how to find out the weight of any vnknowne bullet, by the weight of a knowne bullet of the like mettall, ſo that multiplying the number of euery ſeuerall ſort by the weight that one of them weigheth, and adding all the products into one ſumme; and then diuiding that totall by 2240 pound, which is the pounds in a Tun, the quotient will ſhew you how many Tun all thoſe bullets weigheth.

Example.

Admit the Cannon ſhot weigh 60 pound a peece, by which I multiply 500 (the number of that kinde of bullet) ſo ariſeth 30000 pound weight, and then there is 800 demie Cannon ſhot of 32 pound weight a peece, which multiplied as before, makes 25600 poũd weight. And then there is 900 Culuering ſhot of 16 pound weight a peece, which makes 14400 pound weight. And then 1000 demie Culuering ſhot of 10 pound weight a peece, which makes 10000 pound weight. And then 1100 Saker ſhot of 5 pound weight a peece, which makes 5500 pound weight. And then 1200 Minion ſhot of 3 pound weight a peece, which makes 3600 pound. And laſtly, 1400 Fawcon ſhot of 2 pound weight a peece, which makes 2800 pound weight. All theſe ſummes added together makes 91900 pound weight, which diuided by 2240, yeelds in the quotient 41 Tun, and 60 pound weight remaining.

In this order you may know how many Tun weight any number of ſhot weigheth, ſo that knowing how many Tun any ſhip is of burthen, you may eaſily know how many ſhot will load the ſaid ſhip.

How any Gunner or Gun founder may by Arithmeticke skill, know whether the trunions of the peece bee placed rightly on the peece or not.

Measure the length of the bore of the peece, from the mouth to the breech, diuide that measure by 7, and multiply the summe that commeth in the quotient by 3, the product will shew you how many inches or other measure the trunions ought to stand from the end of the lowest part of the concauitie of the said peece at the breech,

And note that the trunions ought so to be placed, as $\frac{2}{3}$ parts of the circumference of the peece may be seene in that place whereas the trunions are set.

Example.

Admit the cilinder or concaue of a Cannon, or other peece of Ordinance be 10 foot $\frac{1}{2}$ long, I demand where the trunions of the said peece ought to stand?

Answer.

Reduce the length of the concaue of the peece into inches, you haue 126 inches, the which diuided by 7, the quotient is 18, that multiplied by 3, makes 54 inches, or 4 foot $\frac{1}{2}$, so farre ought the trunions to bee placed from the breeeh or lowest part of the hollow concauitie of the said peece.

Another way.

Or multiplying the length of the concaue of the peece by three, and diuiding the product by 7, the quotient will shew the true place, how farre the trunions

ought

ought to ſtand from the loweſt part of the bore or concauity of the peece.

Example.

126 inches the length of the concaue of the peece, multiplied by 3, makes 378 inches, which number diuided by 7, the quotient is 54 inches as before.

And note that the trunions of euery peece were inuented to hold the peece vp in her cariage, to moue her vp and downe to make a perfect ſhot, and to hold her faſt in her cariage after ſhe is diſcharged : for if the trunions be placed too neere the mouth, the peece will be too heauy towards the breech, ſo as the Gunner appointed to ſerue with her, ſhall haue much adoe to raiſe her, to coyne her vp or downe, or being placed too neere the breech, the contrary will happen.

How you may know what empty caske is to be prouided to boy or carry ouer any peece of Ordinance ouer any riuer, if boates or other prouiſion cannot be gotten.

It is thought ſufficient that 5 Tun of empty caske will ſwimme and carry ouer a Cannon of 8 or 9000 pound weight, 4 Tun will carry ouer a demy Cannon, 3 Tun a Culuering, and 2 Tun a Saker, accounting all prouiſions to be made faſt thereto, as plankes, ropes, &c. ſo that knowing what number of Ordinance is to be ferried or carried ouer any riuer, adding all their weights into one ſumme, by framing the Golden rule, you may preſently know what empty caske is to bee prouided to ferry ouer all the ſaid Ordinance at one inſtant.

Example.

Example.

If a Cannon of 8000 weight require 5 Tun of empty caske, how much emptie caske is to be prouided to carry ouer ſo many Ordinance as is ſuppoſed to be 100000 weight?

Reſolution.

I multiply 100000 by 5, ſo ariſeth 500000, the which being diuided by 8000, the quotient is 62 $\frac{1}{2}$, ſo many Tun of emptie caske is to be prouided to carry ouer ſo many Ordinance as weigheth 100000 pound weight. The which empty caske made faſt head to head a row on each ſide, by ſuch as haue skill in ſuch ſeruices, and planked aboue, would ſerue for a bridge to carry ouer a whole Army with all prouiſions thereto belonging.

All which neceſſaries in time of ſeruice, & many more, belongeth to the Maſter of the Ordinance his office, to haue in readineſſe, as alſo to bee prouided of Trunkes, Arrowes, Balls, and all kinde of fire-workes, wet or drie, and the receits for making thereof. As alſo engines for mounting or diſmounting of Ordinance, Wheeles, Axeltrees, Bullets, Powder, Ladles, Sponges, Ropes, Shouels, Anchors, &c. Alſo it is the duety of the Maſter of the Ordinance, the Maſter Gunner, and euery chiefe officer or quarter Maſter vnder them, to be expert in the Art of Gunnerie, the better to teach and inſtruct their inferiours, the which without ſome practice in Arithmeticke and Geometry they cannot well accompliſh. They ought to haue ſome ſight in the Mathematicalls, the better to teach and inſtruct ſuch as would ſhoote at all randons, to know what Ordinance is conuenient for an Army, or to batter or beate downe the walls of any Towne or Caſtle, to know what powder and ſhot is to be

prouided

prouided for that or ſuch like purpoſe, what cariage horſes, labourers and other neceſſaries is to bee allowed for the ſame. They ought to practiſe all Geometricall inſtruments, for the meaſuring of heights, lengths, breadths, depths, &c. To practiſe how to conueigh mines vnder the ground, and how the ſame ſhould bee truely wrought, to blow vp any Towre, Caſtle, &c. To know what length the mine will containe with all his windings to and fro to the place appointed. To haue skill, in the handling of all engines and inuentions belonging to the Ordinance. To appoint to euery peece of Ordinance in time of ſeruice, Gunners that know perfectly how to mannage their peeces, to charge, ſhoot, clenſe, ſcoure, wad and ram the ſame, and what labourers are to attend thereon. To know in euery platforme appointed, how to place the baskets or gabbions, and what proportion of wideneſſe, height, or thickneſſe they ought to containe: and that the loopes haue their due proportion of wideneſſe. To ſee that euery Gunner be able to diſcharge his dutie, and not for fauour or affection to preferre ſuch as can ſay moſt, and doe leaſt: but that euery man bee preferred to place of credite, and eſteemed according to his honeſt behauiour and skill in this ſingular Art. That none bee permitted to the profeſſion of a Gunner, but that he be firſt truely inſtructed in the principles of the Art, by ſuch as haue skill therein. And not to make or ſuffer euery tagge and ragge to bee a Gunner, as is too much vſed in theſe dayes in Townes of garriſon, who was neuer practiſed in the Art, nor hath diſcretion nor deſire to practiſe therein: a great number of ſuch haue but onely the bare name of a Gunner, although their ſtanding hath beene of long time: for as a

great many of Marriners haue ſaild 7 or 8 yeeres, and yet farre from a Nauigator, ſo a great many ſuch haue continued in pay a large prentiſe-hood, and yet farre from a good Gunner. Such in time of ſeruice would worke as the builders did at the Tower of Babell, when one cald for one thing, he had deliuered a contrary thing. In ſeruice the Prince by ſuch is not truely ſerued, the Art leſſe eſteemed, and themſelues diſcredited.

The Art is like to a circle without end, or like to a Labyrinth, wherein a man being well entred in, knoweth not how to get out againe, and therefore it muſt bee exerciſe and induſtrie that muſt make a perfect Gunner. Many things here could I write pertaining to the duety of a Gunner, and euery officer pertaining to the Ordinance, but for as much as the ſame is not peculiar to this Arithmeticall Treatiſe, and ſufficiently handled by other Authors, I omit.

How to know the true time that any quantitie of Gunmatch being fiered, ſhall burne, to doe an exploit at any time deſired.

Take common match, and rub or beat the ſame a little againſt ſome poſt or ſtoole to ſoften it, and then either dip the ſame in ſalt-peter water, and drie it againe in the ſun, or elſe rub it in a little powder and brimſtone beaten very ſmall and made liquid with a little Aqua vitæ, and dried afterwards. Now when you would occupie the ſame, trie how long one yard will burne, which ſuppoſe to be $\frac{1}{4}$ part of an houre, then 4 yards will be a iuſt houre in burning. Now ſuppoſe you haue laid ſome powder or balls of wilde fire to burne ſome houſe, ſhippe, mine, corne-ſtacks, &c. or that you haue placed the ſaid powder

der or balls in ſome ſecret place to burne ſome thing you are deſirous to ſpoile, and that you would be going from the place 3 houres before it effect, then binding the one end faſt to the balls, laying looſe powder vnder & about the ſame, or wrapping the one end like a wreath amongſt the powder looſely, draw out the other end, or lay it crookedly, or wrap it ſoftly about ſomething, ſo as one part doe not touch another, and fire it at the other end: which match ſo drawn or rolled, being iuſt 12 yards in length, ſhall kindle the thing you would burne at the end of 3 houres, according to your deſire: for the rule of proportion ſheweth, that if one yard require a quarter or $\frac{1}{4}$ of an houre, that 12 yards of match will burne out in 3 houres. The like order you may obſerue, to anſwer to any time appointed.

How by Arithmeticall skill you may know what number of men, horſes, or oxen, is ſufficient to draw any peece of Artillerie, and how much euery one draweth a peece, ſo as they all draw together.

Queſtion.

If 90 men bee able ſufficiently to draw a Cannon of 9000 pound weight, accounting carriage and all, I demand how many men is able to draw a Culuering of 2500 pound weight, and how much euery man drew for his part?

Reſolution.

I anſwer: If a Cannon of 9000 pound weight, require 90 men, the quotient ſheweth mee that a Culuering of 2500 weight requireth 25 men to draw the ſame: and diuiding the weight of the peece to bee drawne by the number of men appointed to draw the ſame, the quotient will ſhew you how much euery man drew to his part (to wit) 100 weight.

To know how many horſes is to be prouided to draw any peece Of Ordinance, and how much euery one drawːth.

Queſtion.

If three horſes draw a Fawcon of 900 weight, how many horſes will draw a Culuering of 3000 weight?

Reſolution.

I ſay as before, If a peece of 900 weight require 3 horſes, what will a peece of 3000 weight? and in working according to the rule, the quotient is 10, ſhewing that 10 horſes muſt bee prouided to draw a Culuering of 3000 weight. Alſo diuiding 3000, the weight of the ſaid peece, by 10 (being the number of horſes) there will ſtand in the quotient 300, ſhewing the draught of each horſe.

To know how many Oxen is to be prouided to draw any peece of Artillerie.

It is to be noted that 3 yoake of Oxen is thought to draw as much as three horſes, and that 3 yoake of Oxen is ſufficient to draw a Saker of 1400 weight.

Queſtion.

How many Oxen muſt be prouided for a Cannon of 8000 weight?

Reſolution.

In working as before, I find that 34 oxen, or 17 yoake of Oxen, will ſerue to draw a Cannon of 8000 pound weight. And note that whereas there doth remaine $\frac{2}{7}$ parts of a whole number, neither men, horſes, nor other cattell, can in any ſuch millitarie queſtions bee brought into a fraction, but yet the rule it ſheweth that 17 yoake of oxen is ſufficient for the draught of a Cannō of 8000 pound weight, when 3 yoake of oxen ſerue for to draw a Saker of 1400 pound weight.

If

If you diuide the weight of the whole Cannon being 8000 pound weight by 34, the oxen appointed to draw the ſame, the quotient is 235 pound $\frac{5}{17}$: ſo much did euery oxe draw.

How you may wanting both oxen & horſes to draw any peece of Ordinance, know preſently how many men is able ſufficiently to draw the ſame, either on plaine or marriſh ground.

Queſtion.

I ſhewed in a concluſion before, that 3 yoake of oxen would draw a peece of 1400 pound weight, and that 90 men would draw a Cannon of 9000 pound weight; now if there want both horſes and oxen, or that you are occaſioned to draw the ſaid peece through ſome marriſh ground, whereas horſes and oxen cannot paſſe, I demand how many men is ſufficient to hale a Saker of 1400 pound weight through the ſaid marriſh ground?

Reſolution.

If a Cannon of 9000 weight require 90 men to draw the ſame, I finde that a Saker, weighing 1400 pound weight muſt haue 14 men to draw the ſame, and euery one ſhall draw 100 weight for his part.

In drawing Artillery through any ſoft marriſh ground it is requiſite to haue in readineſſe, in the Maſter of the Ordinance his carts, which carrieth the prouiſions for the Ordinance, certaine hurdels of boords, or rather flat bottomed boates, in which any peece of Ordinance may be placed carriage and all, and by force or ſtrength of men may bee drawne as eaſily, as to draw the ſaid peece on the firme land, for that the ſaid boate is apt to

ſlide or ſwimme on the ſoft owiſh, the ropes being made faſt to the foreſtearne or ſides of the ſaid boates, which boates doe ſerue alſo for carriage of the Ordinance, and all things thereto belonging, ouer any riuer or ſoft owiſh ground, &c.

How you may by the rule afore, know how many oxen will draw any peece of Ordinance, if you want men and horſes.

I ſhewed that 90 men are able to draw a Cannon of 9000 pound weight, and that three yoake of oxen will ſerue to draw a Cannon of 1400 pound weight: now wanting men and horſes, I ſay, If a Saker of 1400 pound weight require 6 oxen, what will a Cannon of 9000? and in multiplying the weight of the Cannon by 6, the number of oxen appointed to draw the Saker, and diuiding that product by the weight of the leſſer peece, the quotient is 38 oxen or 19 yoake, ſo many muſt bee prouided to draw a Cannon of 9000 pound weight, which weight diuided by the 38 oxen appointed to draw the ſame, the quotient ſheweth that euery oxe drew 236 pound weight.

How you may wanting men and oxen to draw any peece of Ordinance, know how many horſes is requiſite to draw the ſame.

Alſo I noted before, that 3 horſes would ſerue to draw a Fawcon of 900 pound weight: I demand how many horſes will ſerue to draw a Cannon of 9000 pound weight?

weight? In working as before, the quotient is 30, ſo many horſes is requiſite for that purpoſe: which peece, her weight diuided by the number of horſes appointed to draw the ſame, the quotient ſheweth that euery horſe drew 300 pound weight. In this order you may know what number of men, horſes or oxen, is able to draw any peece of Ordinance, and what euery one ſeuerally doth draw.

How to know how many 100 *of Haberdepoize weight any peece of Ordinance, or other groſſe weight containeth.*

In the concluſions afore ſet downe, thou muſt note, gentle reader, that euery 100 weight of moſt things, is accounted after fiue ſcore to the hundreth: but if thou be deſirous to know how many hundreth of Haberdepoize weight any peece of Ordinance or other groſſe weight containeth, thou maiſt by Arithmatick ſoon be reſolued; for euery 100 of Haberdepoize weight containeth 112 pound, the halfe hundreth 56 pound, the quarter 28 pound, and the pound 16 ounces: ſo that diuiding the weight of any great peece by 112, thou maiſt eaſily know how many hundreth of Haberdepoize weight the ſame containeth.

I would know how many hundreth of Haberdepoize weight is in a Cannon of 9000 pound weight, I diuide the ſame by 112 as aforeſaid, and the quotient being 80 $\frac{40}{112}$, ſheweth that a Cannon of 9000 pound weight containes 80 hundreth of Haberdepoize weight, one quarter and 12 pound.

A Tun containeth 2000 of Haberdepoize weight.

How

How you may proportionally proone all ſorts of peeces of Artillerie for ſeruice whether they will hold or no.

All peeces that ſhoote a bullet vnder 10 pound weight, and duely fortified with mettall, being ſhot 3 times, firſt with the whole weight of the Iron bullet. Secondly with $\frac{5}{4}$ parts thereof, and laſtly with $\frac{3}{2}$ parts of the ſame, will hold for any ſeruice, being charged with her ordinary charge, albeit the ſaid peece were diſcharged 100 times in one day.

How you may finde out the proportionall charge aforenamed, as thus.

Suppoſe a peece ſhoote a bullet of 6 pound weight, and that you deſire to know what $\frac{5}{4}$ parts in powder of the weight of the bullet is: multiply the weight of the ſaid bullet by the numerator 5, and diuide by the denominator 4, the quotient is your deſire.

Example.

6 multiplied by 5, is 30: the ſame diuided by 4, the quotient is $7\frac{1}{2}$. The like order you muſt vſe in giuing her $\frac{3}{2}$ parts in powder to the weight of the ſhot, and your quotient is 9 pound.

How to proone any peece that ſhooteth a bullet vnder 50 pound weight, and aboue 10 pound weight.

Any peece that ſhooteth a bullet aboue 10 pound in weight, and vnder 50 pound, would for the firſt ſhot be charged with $\frac{2}{3}$ parts in powder of the pellets weight: for the ſecond ſhot with $\frac{5}{6}$ parts, and laſtly with the whole weight of the bullet.

Example.

Example.

Admit a peece ſhoote a bullet of 40 pound weight, the $\frac{2}{3}$ partes thereof is 26 pound $\frac{2}{3}$, and $\frac{1}{6}$ partes thereof is 33 pound $\frac{2}{3}$ parts.

And note, that in prooving any peece of Ordinance, whether ſhe be ſeruiceable or not, her mouth would bee mounted to 20 or 30 degrees of the quadrant, or therebout.

To know how much one coyler rope, for the draught of any peece of Ordinance is bigger than another, and how thicke any of them is.

Take the compaſſe of the leſſer, and likewiſe the circumference of the greater, abating the leſſer out of the greater, the remaine is your deſire; which known, by the rule of proportion you may find out the height or thickneſſe of the leſſer.

Example.

Suppoſe you haue a coyler rope of 6 inches compaſſe, and another of 4 inches compaſſe, abating 4 inches from 6 inches, the compaſſe of the greater, reſts 2 inches, the diameter or height of the greater: which knowne, frame the rule of proportion, ſaying: If 6 yeeld 2, what 4? the quotient is one inch $\frac{2}{3}$ parts, ſhewing the true thickneſſe or height of the leſſer.

To know how much one coyler rope is more than another.

Take the compaſſe of your rope, and multiply it in it ſelfe, and looke how much you would haue the other greater, augment your product by the ſame proportion, extract the ſquare roote, you haue your deſire.

Example.

A coyler rope of 6 inches compaſſe ſquared, makes

36 inches. Now if you would haue one 3 times as much, then multiply 36 by 3, the product is 108, the ſquare roote thereof is 10 inches and ſomething better, and ſo thicke ought a rope to be that is 3 times the compaſſe of the other.

How by knowing the weight of a faddome of one rope, to know the weight of a faddome of any other.

A cable or coyler rope of 10 inches compaſſe weighing 16 pound euery faddom, how much will a faddom of that rope weigh, that is 15 inches compaſſe, and made of the ſame ſtuffe? I multiply the greater in it ſelf, ariſeth 225, and that multiplied by 16 pound the weight of a faddom of the leſſer rope, ariſeth 3600.; the which diuided by 100, being the ſquare of the leſſer rope, the quotient is 36 pound, and ſo much will euery faddome of the greater rope weigh. In this order by knowing what a faddome of the greater rope weigheth, you may ſoone finde what a faddom of the leſſer rope weigheth.

How by knowing the quantity or compaſſe of any ſmall rope, to find out the ſame in another that is many times that bigneſſe.

Admit I haue a ſmall rope of 3 inches compaſſe, and that it is required to know the height of another that is 5 times that compaſſe. I ſquare the number 3. ariſeth 9; which multiplied by 5, makes 45, the ſquare roote thereof is 6 inches $\frac{1}{4}$: ſo high is the greater. The like is to bee done of all ſuch like demands.

To know the weight of a whole coyler rope for the draught of any peece of Ordinance.

Queſtion.

There is a coyler rope of 8 inches compaſſe, weighing 12 pound euery faddome, I demaund the whole weight of that rope being 20 faddome long?

Reſolution.

Multiply the number of faddoms in the rope (being 20) by the weight of one faddome, the product is 240 pound weight, your deſire.

The length of a coyler rope for a whole Cannon ought to be 70 faddome or thereabouts.

For an ordinary Cannon 64 or 66 faddome, and for a demy Cannon 60 faddome or thereabouts.

For a Culuering 46 faddome, a demy Culuering 36 faddome, and a Saker 30 faddome, &c.

To find out the ſuperficiall content of the hollow concauity of any peece.

If you multiply the length of the cilinder or bore of the peece, by the circumference of the hollow concaue about the mouth, the product will ſhew you the ſuperficiall content of the cilinder of the ſaid peece.

Example.

A Cannon of 7 inches diameter hauing her concaue or hollow cilinder 12 foote in length, how much is the ſuperficiall content thereof?

Reſolution.

Reduce the length of the hollow concaue of the peece into inches, ariſeth 144 inches, which multiplied by 22 inches, the circumference of the concaue at the mouth of the peece, ariſeth 3168 inches, the

ſuperficiall content of the mettall compaſſing the concaue of the peece.

To find out the craſsitude or ſolid content of the cilinder or concaue of any peece.

Firſt, you muſt by the rules taught in the beginning of the booke, find out the content of the baſe or plaine of the concauity at the mouth of the peece, in multiplying $\frac{1}{2}$, the diameter in halfe the circumference; or elſe ſquaring the diameter, and multiplying that product by 11, and diuiding the reſult by 14, the quotient will alſo ſhew you the content, the which multiplied in the length of the cilinder of the peece, the product is your deſire.

Example.

The Cannon aboue named of 7 inches diameter, wrought as is ſhewed, yeeldeth 38 inches $\frac{1}{2}$ at the baſe or circular content of her mouth, which multiplied by 144 inches, the length of the cilinder, yeeldeth 8280 inches, the ſolid content of the concaue of the ſaid peece.

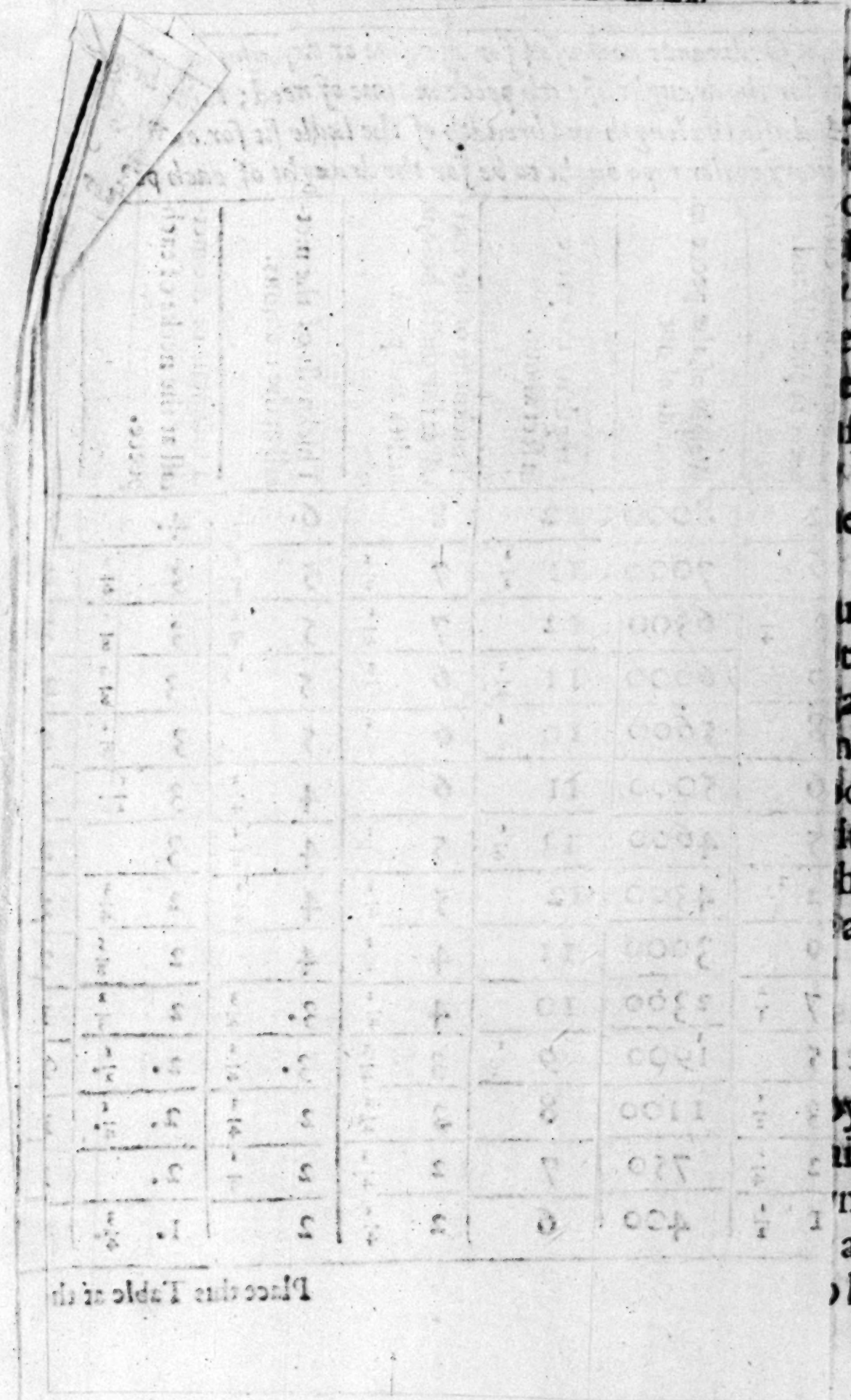
If you deſire to know how many foote in ſquare meaſure, the ſolide content of the empty or hollow concauity of the peece aforenamed, or any other doth containe, you muſt worke thus; deuide the number of inches in the ſolide content thereof by the number of inches in a foote ſquare, being 1728, the quotient is your deſire.

Example.

The ſolide content of the peece of 7 inches diameter aboue named, containeth 8280 inches; which deuided by 1728, the quotient is $4\frac{57}{72}$, that is, 5 feete in ſquare meaſure wanting 15 inches. The like is to bee done in any other peece, or in meaſuring the cilinder or Cone in any other ſolide body.

How

How you may Arithmetically know how much any peece of Ordinance is taper-bored, or whether the same



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How you may Arithmetically know how much any peece of Ordinance is taper-bored, or whether the ſame be taper-bored, or not.

Put vpon your rammer ſtaffe a tampion of wood, that is iuſt the height of the hollow concaue of your peece, and thruſt the ſame home into the peece; if it goe not home to the breech, then the peece is taper-bored; if it goe home, the peece is not taper-bored: if ſhe bee taper-bored, then put on ſuch a tampion of wood vpon your rammer-ſtaffe, as may fill the concaue of the peece in the narroweſt part where ſhe is taper-bored, and be ſure that it goe home to the breech of the peece, and afterwards with your compaſſes, meaſure the diameter of either tampion, abating the leſſer meaſure out of the greater, the remaine is your deſire.

And note, that the tampion at the end of euery rammer-ſtaffe, is to thruſt home the wad and bullet cloſe to the chamber or place where the powder lyeth, and euery rammer-ſtaffe ought to haue a ſponge at the one end, to cleanſe the peece with, and a tampion of wood at the other end, to put home the bullet and wad with, in the center of which ought to be a hollow ſcrew, wherein the Gunner may ſcrew in a wad hooke to vnloade any peece at his pleaſure.

How to ſhoote in any morter peece.

Morter peeces were inuented onely to annoy the enemy, when other Ordinance cannot be vſed againſt them, as being charged with ſtone ſhot to beate down the houſes of the enemy, or to fal amongſt men being aſſembled together, or charged with balles of wild-fire to burne the

A Table wherein you may finde the names of the great Ordinance now vsed for offensiue or defensiue seruices; the height
the number of Men, horses, or oxen, requisite for the draught of each peece in time of need; the height weight,
to charge euery great peece of Artillery. And also the length and breadth of the ladle fit for euery peece; As t
blanke and vtmost range. And how long euery coyler rope ought to be for the draught of each peece, after the a

The names of the peeces of great Ordinance.	The height of the diameter of euery peece, in inches and parts.	Height of the bullet in inches and parts.	Weight of the shot in pounds and parts.	Compasse of the shot in inches and parts.	Weight of corne powder due to charge each peece in pounds and parts.	Weight of the peece in pounds about.	Length of the peece in feet about.	Thicknesse of the mettall at the touch-hole, in inches and parts.	Thicknesse of the mettall at the trunions.	Thicknesse of the mettall at the necke of each peece.	Length of the ladle in inches and parts.
Cannon.	8	7 1/4	64	25 1/7	32	8000	12	8	6 3/4	4.	3. 1/2.
Cannon Serpentine.	7 1/2	7 1/4	52	23 4/7	26	7000	11 1/2	7 1/2	5 2/3	3 1/4	2.
French Cannon.	7 1/4	7	46 3/4	22 11/14	23 1/4	6500	12	7 1/4	5 2/3	3	11.
Demy Cannon eldest.	6 3/4	6 1/2	36 5/8	21 3/14	20	6000	11 1/4	6 3/4	5 1/4	3 3/8	22.
Demy Cannon ordinary.	6 1/2	6 1/4	32	20 3/7	18	5600	10 1/2	6 1/2	5	3 1/8	20.
Demy Cannon.	6	5 3/4	24 1/2	18 6/7	16	5000	11	6	4 3/4	3 1/16	21.
Culuering.	5 1/2	5 1/4	19	17 2/7	15	4600	13 1/4	5 1/2	4 1/2	3	22.
Ordinary Culuering.	5 1/4	5	16 1/4	16 1/2	12 1/2	4300	12	5 1/4	4 1/4	2 3/4	21.
Demy Culuering.	4 1/2	4 1/4	11 3/4	14 1/7	9	3000	11	4 1/2	4	2 5/8	20.
Demy Culuering something lesse.	4 1/4	4	9	13 5/14	7 2/3	2300	10	4 1/4	3. 3/4	2 2/3	19. 1/2.
Saker ordinary.	3 3/4	3 1/2	6	11 11/14	5	1900	9 1/2	3 3/4	3. 1/4	2. 1/2.	16.
Sakeret or Minion.	3 1/4	3.	4 3/4	10 3/14	3 1/2	1100	8	3 1/4	2 3/4	2. 1/4.	14.
Fawcon.	2 3/4	2 1/2	2 1/2	8 9/14	2 1/4	750	7	2 3/4	2 1/3	2.	12.
Fawconet.	2 1/4	2.	1 1/8	7 1/14	1 1/2	400	6	2 1/4	2	1. 3/4.	10.

Place this Table at the 87 pag

e height of their diameters, their weight, and length, the thickneſſe of their mettall at the breech, trunions or necke: veight, and compaſſe of the bullet belonging to euery peece of Artillery: And how much corne powder is requiſite ; As the length, breadth, depth, or thickneſſe of the carriage of each peece, the diſtance each peece ſhootes at point ter the account in feet and inches of Aſsize of England, and Habberdepoiz weight of the ſame.

Length of the ladle in inches and parts.	Breadth of the ladle.	Length of the planks of the carriage in feet.	Breadth or depth of each planke at the fore-end in inches.	Breadth of the planks at the lower end.	Thickneſſe of the planks in inches and parts of inches.	The number of men ſufficient to draw each peece in ſeruice.	The number of horſes requiſite to draw each peece of Ordinance.	The number of yoake of oxen fit to draw each great peece.	Diſtance of paces the peece carrieth at point blanke about.	Diſtance of paces each great peece ſhoots at vtmoſt randon about.	The length of the coyler rope requiſite to draw each peece.
3. ½.	15.	16. ¾.	32.	20.	8.	90	16.	17.	300.	1500.	70.
2.	14. ½.	16. ¼.	20.	18. ¼	7. ½.	80.	14.	15.	340.	1600.	66.
I.	13. ½.	16. ¾.	29.	18.	7. ¼.	70.	12.	14.	360.	1740.	64.
2.	12.	15. ½.	27.	16. ¾	6. ¾	65.	11.	12.	370.	1800.	60.
0.	11. ½.	15. ¼.	26.	16. ¼	6. ½	60.	10.	11.	350.	1700.	54.
I.	11.	16.	24.	15.	6.	56.	9.	10.	340.	1600.	46.
2.	9. ½.	18. ¼.	22.	13. ¾	5. ½	50.	8.	9.	420.	2100.	40.
I.	9.	17. ¾.	21.	13. ⅛	5. ¼	46.	8.	9.	400.	2000.	36.
0.	8. ½.	16. ⅛.	18.	11. ¼	4. ½	36.	7.	8.	380.	1800.	34.
9. ½.	7. ¾.	14. ⅜.	17.	10. ¾	4. ¼	28.	6.	7.	320.	1600.	30.
6.	6. ¾.	14.	15.	9. ⅜	3. ¾	24.	5.	6.	300.	1500.	28.
4.	5.	11. ½	13.	8. ⅛	3. ¼	20.	4.	4.	280.	1400.	24.
2.	4. ½.	10. ¼.	11.	7.	2. ¾	16.	3.	3.	260.	1200.	20.
0.	3. ¾.	8. ⅔.	9.	6. ½	2. ¼	10.	2.	2.	220.	1000.	20.

87 page.

enemies ſhips, houſes, or corne. To make a perfect ſhot in one of theſe peeces, it is requiſite you know 2 things belonging to the ſame (that is to ſay) how far your morter-peece will carry a bullet, or a ball of fire-worke, as ſhe is to ſhoote at the beſt of the randon: and likewiſe how far it is from your peece to the mark you intend to ſhoot at, which knowne you may make a perfect ſhot as thus.

Example.

If a morter-peece ſhoote a bullet or fire-worke 700 paces, and that the marke which you intend to ſhoote at is but 500 paces; I demand at what degree of the quadrant, ſhall the peece be layd at, to make a good ſhot?

Reſolution.

To anſwer this and all ſuch like, reaſon and experience teacheth, that the leſſer ground you intend to ſhoot, you muſt raiſe the mouth of your morter peece ſo many degrees aboue the beſt of the randon, as is ſufficient to reach the marke deſired: and therfore I ſay, If 700 paces require 45 degrees of the quadrant, what will 500? and the quotient tels me, that at 63 degrees of the quadrant the mouth of the ſaid peece muſt be eleuated at, to cauſe the bullet or fire-ball to light accordingly.

If you abate 45 degrees (being the beſt of the randon) from 63 degrees, that the peece was eleuated at, the remaine is 18 degrees, and ſo many degrees of the quadrant was the mouth of the morter peece eleuated at to reach the marke.

To know how farre or ſhort any morter-peece will ſhoote further or ſhorter, at the mount or diſmount of one or many degrees.

Queſtion.

A morter-peece that ſhoots 450 paces at the beſt of the

the randon, I would know how much ſhorter ſhall ſhee ſhoote, being elcuated one degree aboue the vtmoſt range?

Reſolution.

Diuide the diſtance of the vtmoſt range being 450 paces, by 45 the degrees in the beſt of the randon, the quotient is 10; ſo many paces will the ſaid peece ſhoote ſhorter, her mouth elcuated one degree.

How you may know very neare how farre from your peece the bullet ſhall light, the ſaid morter-peece mouth being raiſed to what degree you thinke good.

Queſtion.

Suppoſe there is a Caſtle, &c. beſieged, and that the Gunners had brought their Ordinance as neere as they would wiſh, ſo that hauing diſcharged the morter-peece in the former concluſion, at the mount of 60 degrees, they find that the bullet fals in, or about the midſt of the ſaid Caſtle or Fort. The queſtion is, how farre it is betweene the peece and the fall of the ſaid bullet?

Reſolution.

You muſt firſt ſeeke what difference of degrees is betweene 60 and 45, and you ſhall find 15; then by the rule of proportion ſay, If one degree abate 10 paces, what will 45? and you ſhall find 150 paces in your quotient. And in this order by the helpe of Arithmeticke, you may find how farre it is from the peece to the marke.

Alſo it is poſſible to ſhoote ſo directly vpright in a quiet,

quiet, faire, and calme day, that the bullet ſhot out of your morter peece, ſhal fall into the peece mouth againe, or hard beſides the ſame, if you raiſe the peece-mouth iuſt to 90 degrees of the quadrant, which albeit it bee not ſeruiceable, yet it is poſsible to be done: For this is a generall rule, that no peece of Ordinance whatſoeuer can ſhoote a bullet to continue ſtill in a ſtreight line, during the motion of the ſaid bullet, except you eleuate or raiſe the concaue of the ſaid peece directly towards the zeneth of the skie, or elſe plumbe downe towards the center of the earth.

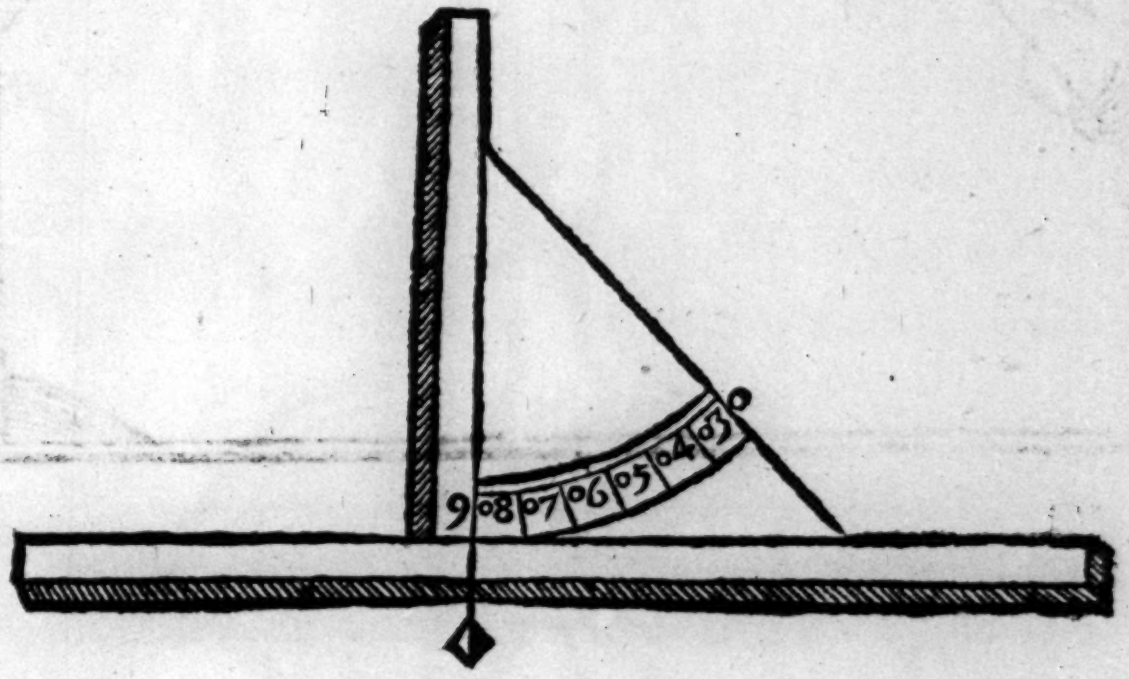
The diameter of the chamber-mouth in euery morter-peece, ought to bee equall to the ſemi-diameter in the mouth of the ſaid morter.

The length of euerie chamber in a morter-peece, ought to be once and a halfe the diameter of the chamber.

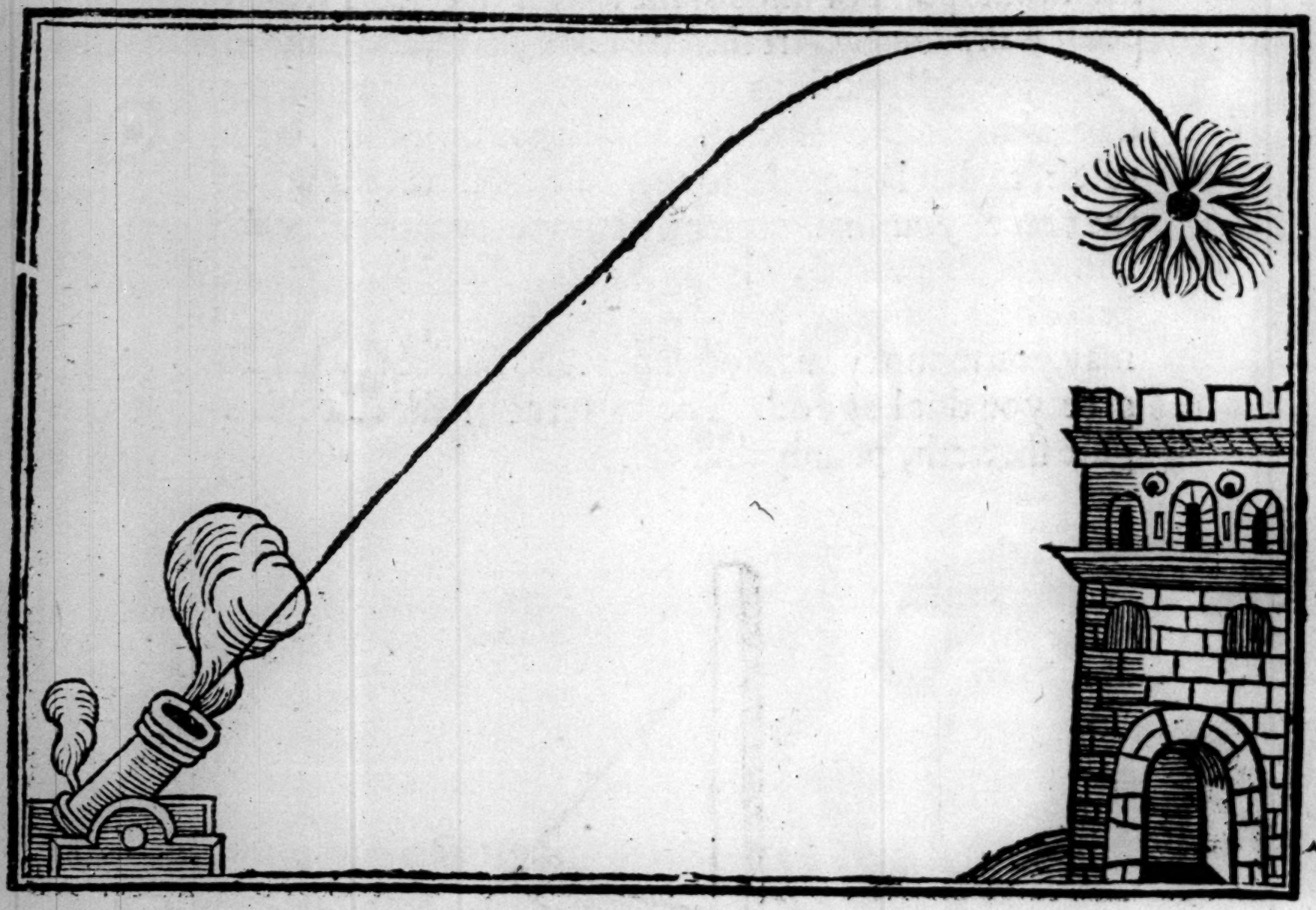
The mettall at the breech of euery morter-peece, ought to be fortified equall in thickneſſe to the diameter of the mouth of the chamber within, and at the trunions to the ſemi-diameter, and at the fore-part or necke of the peece, to the $\frac{1}{3}$ part of the diameter of the chamber mouth.

To mount a morter-peece by the quadrant, ſome vſe to put the rule of the quadrant into the peece-mouth, cloſe to the mettall, or inſide of the peece, noting at what degree the plummet hangs: but foraſmuch as there bee many morter peeces a little taper-bored at the mouth, (I meane the diameter at the mouth is ſomething wider than it is within) therefore it is the beſt to haue a rule made for the purpoſe, which among the experienced Gunners is common, the ſaid rule being about 18 inches

ches length, at the middle point or pricke whereof is another ſhorter rule, framed artificially aboue a foote long, ioyned cloſe, and falling perpendicularly on the longer rule, whoſe containing angle lighteth iuſtly on the middle point or mids of the longer rule, from which point is drawne by Art the $\frac{1}{8}$ part of a circle, and diuided into 45 equall diuiſions or degrees, ſo as the 90 degrees ſtands iuſt on the center or middle point of the longer rule: ſo that laying the longer rule croſſe the mouth of the peece, you ſhall preſently know at what degree the ſaid morter peece is eleuated at by the plummet, the peece being mounted at any grade aboue 45. And thus may you mount your morter peece, to ſhoote at what degree you thinke good. The patterne of the rule this figure ſheweth, plainly drawne.



The orderly flight or motion of the bullet or fire-ball ſhot out of any morter peece, by the figure or draught hereunder may be perceiued.



Haning

Hauing planted Ordinance vpon any mount or platforme, to beſiege any Towne &c. and that you deſire to make ſome little trench or ditch about the ſame for the defence thereof, how you may know how much the earth and turfe that is caſt out of the ſaid ditch, ſhall raiſe a wall in height, being laid orderly at the brim of the ſaid ditch, on the inſide thereof, making the ſame wall to any proportion aſsigned.

Queſtion.

Suppoſe the Generall command the Captaine of the Pyoners, that a ditch be made about the mounts or platformes where the Ordinance plaies, making the ſame 18 foote in bredth at the brim, 12 foote in bredth at the bottome, and 8 foote in depth, and that the earth and turfe digged out of the ſaid trench be laid orderly in the inſide thereof at the brim of the ſaid ditch, ſo as a wall may bee made in bredth at the bottome 12 foote, and at the top 8 foote, I demand how high ſhall that wall bee when it is finiſhed?

Reſolution.

To worke this, there is a generall rule, (as thus.) Adde the wideneſſe or breadth of the brim, and the breadth or wideneſſe at the bottome together, the $\frac{1}{2}$ of that addition multiplied by the depth of the ditch, the product of that multiplication ſhall bee your diuident, or number to be diuided. Now to finde the height of the wall, adde the thickneſſe of the bottome of the wall which you meane to make, to the thickneſſe or bredth that you intend to make it at the head; the $\frac{1}{2}$ of that addition ſhall bee your diuiſor, which diuident diuided by the

diuiſor, the quotient will ſhew you the height of the wall.

Example.

The trench in this concluſion is ſaid to be 18 foote broad at the mouth or brim thereof, and 12 foote at the bottome, which 2 numbers being added, makes 30, the halfe whereof is 15 feete, which 15 feete multiplied by 8 feete being the depth, ariſeth 120 feete for my diuident. Likewiſe, adde twelue foote (the thickneſſe of the wall at the bottome) to 8 foote the bredth you meane to make it at the head, ſo ariſeth 20 feete, the ½ thereof is 10 feete for my diuiſor, (and ſo thicke the ſaid wall will be in the midſt) the which diuident being 120, being diuided by the diuiſor 10, the quotient is 12, and ſo many foote in height ſhall the earth and turfe caſten out of the trench aforeſaid, make a wall being 12 foote broade at the bottome, 8 foote at the head, and 10 foote in breadth at the midſt: the ſaid trench being 18 foote broad at the brim, 12 foote broad at the bottome, and 8 foote deepe.

In this order you may finde out the height, bredth, or depth of any ſuch like wall or ditch, in making the ſame after any proportion aſſigned.

Briefe obſeruations of certaine principals in the Art of Gunnery, for euery Gunner to conſider of, to practiſe and learne, viz.

To know what diſparture euery peece of Ordinance ought to haue in ſhooting either at or within point blanke, or with an inch rule at any aduantage.

To

To vſe a mediocrity in ramming and wadding, and in giuing euery peece her due loading in powder & bullet.

To know the goodneſſe and badneſſe of powder, and how to mixe and make perfit good powder, and how to fine the peter,&c.

To conſider the winde, whether it blow with you or againſt you,or on any ſide of the peece,and how to weather your peece to make a good ſhot.

To conſider the platforme, whether it bee flat, or elſe declining for the recoile of your peece,and whether the marke be higher or lower than your platforme,as alſo to know the diſtance thereto,

To know whether your peece be truely bored or not, and how to make a perfect ſhot in a peece that is not truly bored.

To conſider whether the one wheele be more glad or reuerſe faſter vpon the axle-tree than the other, or whether the one wheele ſtand higher than the other, leſt you doe ſhoote wide.

To know whether a ſhort peeee will out-ſhoote a long peece or not,keeping the length of the marke by the like degrees of the quadrant.

To know that leuelling with the quadrant towards a hill (the marke ſtanding higher than your platforme) you ſhall ſhoote ſhort: and ſhooting into a valley, you doe ouerſhoote the marke, but ſhooting on a leuell ground you keep the length with the quadrant,and how you ought to lay your peece to make a perfect ſhot with the quadrant at euery marke.

To know that giuing leuell with an inch rule (which ſome call the rule of flat) it is erroneous in ſhooting in peeces of contrary length,as alſo at ſeuerall markes: ob-

ſeruing one method.

To learne to know the diſtance to the marke, and what diſtance your peece will ſhoote at point blanke, or mounted from degree to degree (which is the beſt rule to ſhoote by.)

To know whether the cariage or ſtocke of your peece haue her due length or not, and whether the peece bee truly placed therein or not.

To conſider that in ſhooting diuers peeces from one platforme, to diſcharge that peece which ſtands to the ley wards firſt, and to ſet your match or fire euer on the ley ſide, and your powder on the wind hand.

To know the true order in mixing and making all kind of fire-workes, wet and dry.

To know the height and weight of all peeces of Ordinance, and whether the ſame lye ſtreight in the cariage or not.

To know the height and weight of all bullets of like mettall, and the circumference thereof: and what proportion a bullet of one mettall beareth to the like or vnlike bullet of a contrary mettall.

To know how much Serpentine or corne powder is requiſite to charge any peece of Artillery.

To know what neceſſaries belongeth to any peece of Ordinance, being in ſeruice by land or ſea, as ladles, ſponges, hand-ſpikes, ropes, coines, &c. and what labourers ſhould attend the ſame.

To know likewiſe what men, horſes or oxen, bee able to draw any peece of Ordinance in ſeruice, or on the ſudden.

To be circumſpect of lighted matche and candles, &c. for feare of powder, being in ſea-ſeruice: and to keepe

keepe a perfect regiſter of euery thing pertaining to your Ordinance, both what you haue preſent, and what you haue ſpent, to keepe your Ordinance drie within, and to haue in readineſſe all kinde of ſeruiceable fire-workes, which fire-workes ought to bee made either in the boate or on land, but not in the ſhip for feare of had I wiſt.

To know the vſe of all Geometricall inſtruments belonging to the profeſſion of a Gunner, as alſo to haue ſome ſight in Arithmeticke and Geometry, thereby to ſhoote at all randons, and how to mannage and handle all engines, for the mounting or diſmounting of any peece of ordinance, in or out her cariage, &c.

To know that euery peece ought to bee as thicke of mettall in euery part from the loweſt part of the concaue at the breech, to that part of the chamber that holds the powder, as the bullet due to that peece is in height.

A breuiary of certaine ſecrets in the Art of Gunnery.

A bullet violently driuen out of any peece of Ordinance by the force of the powder, flieth ſwifteſt and ſtraighteſt from the mouth, till it be paſt $\frac{1}{3}$ the diſtance of the leuell range.

The great noiſe or rore that the peece makes in deliuering the bullet (or diſcharged without bullet) ariſeth betweene the ayre within the peece, violently driuen out into the open aire by the force of the fire (the Petre or Maſter being reſolued into a windie exhalation.) And according to the quantitie of the fire and aire, burſting out of the peece, ſo is the cracke more or leſſe.

Any bullet ſhot out of a peece lying leuell, doth flie

flie more heauily, and worketh leſſe effect in piercing an obiect, than when the peece is eleuated at any degree or degrees of the randon.

A heauie bullet violently mouing pierceth ſorer than a lighter bullet, hauing the like motion.

A bullet of lead ſhall worke as great effect againſt an obiect, as the like bullet of iron, hauing the like motion, by reaſon of his ouerplus of weight.

A bullet ſhot out of any peece of Artillery, will pierce more againſt any thing ſtanding firme, than againſt a moueable obiect; and ſhot at an obiect a reaſonable diſtance from the peece, will pierce more effectually, than ſhot at the ſame neerer hand.

Euery bullet doth make a long or ſhort range, according to the eleuation of the peece out of which it is ſhot.

A bullet flieth euer furtheſt in his ſtreight motion (or in an inſenſible ſtreight line) the heigher that the peece is eleuated at the mouth.

Any peece diſcharged twice with one and the ſelf like quantity of powder, wad, and bullet, hauing one and the ſelfe like proportion in ramming and wadding, and ſhot at one like degree of randon, the peece of like temper at either ſhot ſhall make like ranges, but the ſaid peece diſcharged as afore, but not of like temper, ſhall make ſeuerall grazes.

Two peeces in all reſpects equall, ſaue onely that the one is ſomething longer than the other, diſcharged with one like quantity in powder and bullet, ſhall make ſeuerall grazes, according to the length of the cilinder of the peece, the longer ſhall out-ſhoote the ſhorter.

Two peeces in all reſpects equall, ſaue onely in length, diſcharged at a marke of equall diſtance from each

each peece, and being within the range of both peeces, the bullet ſhot out of the ſhorter peece, ſhall graze or beate the marke, before the bullet ſhot out of the longer peece.

Two peeces proportionall in all reſpects, being diſcharged with one like quantity and kinde of powder, but differing in bullet, as the one Iron, the other lead, and both bullets of like height, ſhall make ſeueral ranges, the Iron bullet ſhall outflie the leaden bullet, but diſcharged with a bullet of mettall, and afterwards with a like bullet made of wood, obſeruing one and the like quantitie in powder at euery ſhot, the bullet of wood ſhall not flie ſo farre as the like bullet of mettall.

A peece any whit eleuated at the mouth, will ſhoote further in an inſenſible ſtreight line, than lying leuell; and by how much more any bullet is driuen more ſwifter through the ayre, by ſo much it is made the more lighter in the mouing or drift thereof.

Two peeces alike in euery reſpect, ſhot with one like bullet, but different quantitie of powder, ſhall make ſeuerall ranges. Alſo the ſaid peeces and bullets equall in all reſpects, and the powder alſo in quantitie equall, ſauing that the mixtures of the ſaid powder is not alike, ſhall make ſeuerall ranges.

One peece diſcharged diuers times with one like bullet, firſt with the quarter of the weight of the bullet in powder, after with halfe the weight, thirdly with $\frac{2}{3}$ parts of the weight, and laſtly with the whole weight of the bullet in corne powder, and the ranges differing at point blanke noted, the ranges at the vtmoſt randon differing, ſhall be proportionall, one method in charging, &c. being obſerued.

To euery peece of Ordinance, according to the proportion of the diameter, length of the cilinder, and weight of the bullet belonging thereto, there is a due quantity of powder to be allowed, so that charging the peece with more or lesse than the said due proportion, shall rather hinder than further the bullet in his furthest range.

By how much the mettall of any peece is made hotter by often shooting, than it was before you made the first shot, by so much is the concaue or bore of the peece made more attractiue, the mettall dulled and the peece worketh lesse effect than in the beginning.

All peeces in whose mettall is mingled most tin, lead, or copper, is more attractiue a great deale than those peeces in whom is put most bel-mettall.

A brasse peece made hot with often shooting, is more apt to breake than when it is cold; and any peece of Artillery is more apt to breake at the first or second shot in a hard frost being cold, than made hote with often shooting.

Any peece of Ordinance discharged, hauing her full charge in powder, will range and pierce further, than wanting any part thereof; and hauing a little quantitie more than her due charge in powder, will ouershoot the other, but it will danger the peece; but doubling the weight of the bullet in powder, shall shoote lesse ground than hauing a meane proportionall charge in powder (to wit, betweene $\frac{2}{3}$ parts and the whole weight of the bullet) for that the cilinder of the peece is too much choked, and the bullet driuen out into the open aire before the powder be all fired.

Euery peece of Artillery ought to haue her conuenient length and weight of mettall, according to the pro-

proportion of the diameter or bore of the ſame, and being made longer or ſhorter than her ſaid due length, will rather hinder than further her vtmoſt range.

Any peece of Ordinance made hote through much ſhooting, will neither range ſo farre, nor pierce ſo deepe, as being temperately cold.

No peece of Artillery can ſhoot a bullet to range ſtill in a perfect ſtreight line, except you ſhoote the ſame either directly vpright towards the zeneth of the sky, or elſe directly plumme downe towards the center of the earth.

The right line of the vtmoſt randon in all peeces, is more than the right line of the leuell range; and the right line of the vtmoſt range, is not ſo much as the right line of 90 degrees.

The vtmoſt range in all ſorts of peeces, is not at iuſt 45 degrees of randon, as *Tartallia* and diuers others do affirme, but ſhooting with the wind in a quiet or calme day, is at or about 45 degrees, but the wind againſt, or on any ſide, or rough, or the aire thicke, &c. will range as farre at or about 40 degrees.

Two peeces in all reſpects equall ſaue onely in length, diſcharged with a like quantity in powder, wad, & bullet, and ſhot at a marke within the reach of both peeces, mounted at like degrees of randon with the quadrant, the ſhorter peece ſhall outſhoote the longer.

The right lines made by any 2 peeces at one degree of randon diſcharged, are proportionall to the ranges of their bullets at the ſame degrees of randon, and the right lines made by any 2 peeces at any randon, are proportionall to their vtmoſt ranges.

Any peece of Ordinance firſt diſcharged with the whole weight of the bullet in Serpentine powder, & after

diſcharged with $\frac{1}{4}$ the weight of her bullet, in ſuch corne powder as ſhall cauſe the peece to range the ſame ground : and laſtly diſcharged with halfe the quantity of either ſort of powder, the ſecond ranges ſhall not bee equall, although the manner of charging and temper of the peece be all alike.

Three peeces in all reſpects equall, ſaue euery one exceeds other in like proportion in length, the vtmoſt ranges of their bullets ſhall not be alike proportionall, although the forme of charging be vniforme and alike.

A peece twice charged, firſt with an Iron bullet fit for the ſame peece, and after with a leaden bullet of the like weight, but differing in height, and with one and the like quantity in powder and wad, at either time the Iron bullet ſhall outflie the leaden bullet.

A peece diſcharged firſt with an Iron bullet, and after with a leaden bullet of like height, and at either time diſcharged with the weight of the bullet in Serpentine powder, ſhall make vnequall ranges.

A peece twice diſcharged at like degree of randon, firſt with an Iron, and then with a leaden bullet, and after diſcharged with any other quantity of powder, the ranges of the bullets ſhall not retaine the ſame proportion.

If 2 peeces of one length but differing in bore, the one diſcharged with an Iron, the other with a leaden bullet at one like randon, hauing the weight of either bullet in courſe powder, doe range both alike ground, and the ſaid peeces after diſcharged with halfe the weight of their bullets, of the ſame or any other powder, ſhall not range one like diſtance of ground.

Two peeces of one mettall and length, but of different

bullets

bullets equally mounted, discharged with any like quantity of one powder, shall not range iustly one distance of ground.

The proportion of the different ranges, that Iron and leaden bullets make, being found by experience in any one peece of Ordinance, the same proportion will not hold in all other peeces of Ordinance of contrary length, that shootes the same like bullet.

Any peece of Ordinance being thicker of mettall on the one side than on the other, discharged at a marke, will cast the bullet towards that side, that is thickest of mettall.

Two peeces of contrary length, but of like diameter, hauing both one like charge, being shot off at a marke within the reach of both peeces, giuing leuell with an inch rule, at one like height of the rule, shall make seuerall grazes, the shorter peece shall outshoote the longer.

Any peece of Ordinance will conuey the bullet more ground, her mouth eleuated at 18 or 20 degrees, than from the said grades to the best of the randon, although there be 7 degrees vantage in the latter.

Any peece of Ordinance hauing her due loading, will conuey the bullet more than fiue times the distance of her leuell range.

A Table ſhewing the contents of this Booke.

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FINIS.